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NUTS AND VOLTS

EVERYTHING FOR ELECTRONICS

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January 2011

Vol. 32 No. 1

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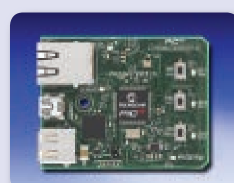

PIC32 Ethernet Starter Kit – DM320004

Multimedia Expansion Board - DM320005

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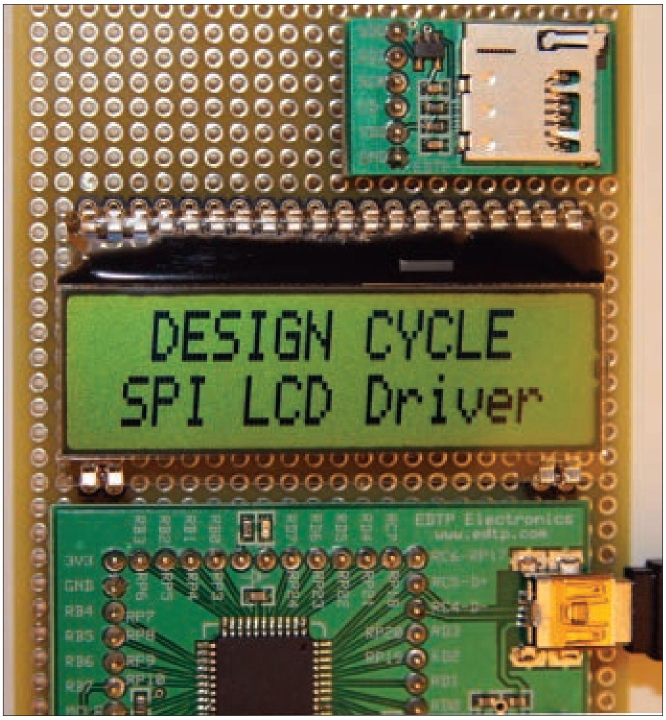

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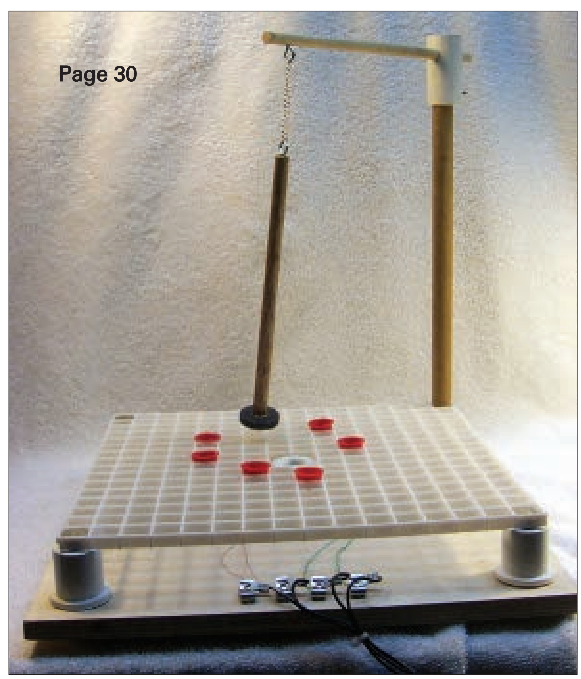

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by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

Modding

A common thread in most of the emails we received in response to my question about the future direction of *Nuts & Volts* was the desire for more and more affordable hands-on projects. As many readers point out, these two goals tend to be at odds with each other. Why would someone spend $20 on parts and shipping, and another $20 on a custom printed circuit board when a superior circuit with a nice case and battery compartment can be had for $15 at a local retailer?

As I've noted in past editorials, one way around the cost issue is to go with a kit. Kits tend to be cheaper than buying parts piecemeal because of reduced shipping costs, especially if you have to order from multiple suppliers. Kits also reduce the risk of failure. You plug in and solder the parts and — assuming you've followed the directions faithfully — the circuit should be good to go. You'll have to pay attention to capacitor and LED polarity, proper orientation of ICs in their sockets, and the like, but that's about it.

While kits are fun — I spent most of my money as a youth on HeathKit projects — they often lack the challenge of building a circuit from scratch. However, it's not an all or nothing proposition. For a great mix of challenge, affordability, and fun, you should try your hand at modding. Modding is simply taking an existing circuit and making it better. Examples of modding include increasing the output power of an amplifier, improving the regulation or efficiency of a power supply, improving the selectivity and sensitivity of a shortwave receiver, increasing the clock speed of a microprocessor, or changing the audio characteristics of a guitar effects pedal.

The **accompanying figure** shows a typical mod sold on eBay for guitar effects pedals. For about $15 (including shipping), you get a small bag of capacitors, resistors, and a chip or two. By replacing the stock components with those from the kit, mod shops claim they can enable your pedal to produce better sound effects.

Every electric guitarist that I know is a modder at heart. They're constantly changing the pickups in their guitars and experimenting with different chip sets, tubes, and passive components in their amplifiers and other music equipment.

Modding can be a good business. While you can get a bag of parts and instructions for $15, most guitar effects pedal modders on eBay charge $50 to $100 for labor. Modding as a source of supplemental income is something to consider in an economic downturn.

The best thing about modding is that you start with just about everything you need. For example, if you're increasing the low frequency response of a stereo amp, you don't have to worry about a chassis (have you priced one lately?), display, controls, and the rest. You can focus your efforts on the power supply and power amplifier circuitry.

It takes a bit of discipline to be a good modder. In contrast with kit building, it's generally a bad idea to make all the changes you have planned and then plug in the equipment. Because you may not be working with a schematic, you could make a mistake that will take you hours to undo if you rush through the project. It's better to make a small change such as changing the capacitors in the signal path and then checking the results rather than to update the power supply, as well. If your circuit stops working because of a mod error, you want to know which mod is responsible. It's a good idea to take good notes when you mod. It's amazing what you can forget when you're interrupted in the middle of a modding project.

By the way, in case you're curious, the mod shown in the figure turned out great. In addition to the standard mod component changes, I rewired the pushbutton switch and made a few other changes that really improved the quality of the distortion produced by the pedal. This highlights another point of modding — start with what's safe and proven, but don't end there. Add your own spice. It'll stretch you as an experimenter and you'll learn a lot more in the process. **NV**

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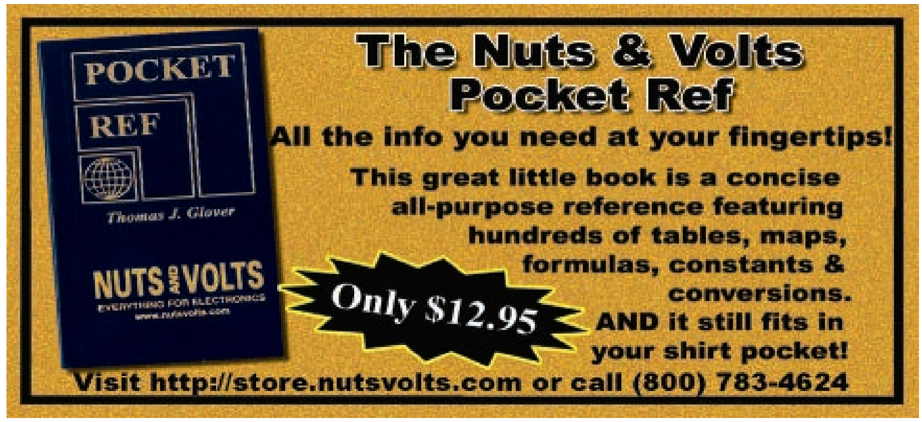
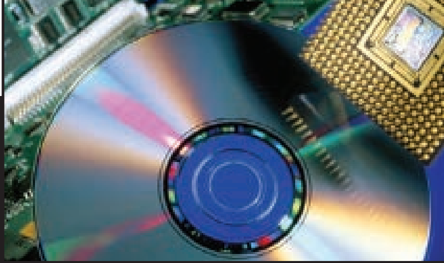




TECH KNOWLEDGEY 2011

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

NEW LASER-BASED MISSILE DEFENSE

Photo courtesy of Lance Cpl. Manuel Valdez.

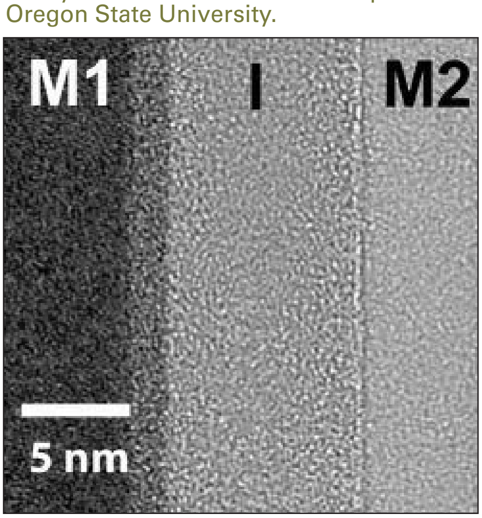
■ A Stinger infrared-seeking missile is launched in a Marine live-fire exercise.

In rough terrain places like Afghanistan, the military has to rely on helicopters for many operations. Because choppers tend to operate at low altitudes and at relatively slow cruise speeds, they are highly vulnerable to shoulder-launched heat-seeking missiles. The good news is that a new laser technology developed at the University of Michigan (**www.umich.edu**) and spin-off Omni Sciences (**www.omnisciinc.com**) looks like a promising solution. Mohammed Islam, a professor in the Department of Engineering and Computer Science, has created an assembly of cheap, off-the-shelf fiber optic components to build a sturdy, portable "mid-infrared supercontinuum laser" that can blind heat-seeking missiles from a distance of 1.8 miles. According to the prof, "Our lasers give off a signal that's like throwing sand in the eyes of the missile." The key is the fact that supercontinuum lasers give off a beam of light with a broad range of wavelengths rather than just a single one. They operate in longer infrared wavelengths that are invisible but can be felt as heat. As a result, the device can mimic an engine's electromagnetic signature and confuse incoming weapons. An additional advantage is the device's simplicity. "The laser-based infrared countermeasures in use now for some aircraft have 84 pieces of moving optics. They couldn't withstand the shake, rattle, and roll of helicopters," Islam noted. "We've used good, old-fashioned stuff from your telephone network to build a laser that has no moving parts." The system — developed with funding from the US Army and DARPA — is likely to have many other military applications, but it is particularly well suited for helicopters. ▲

A NEW APPROACH TO ELECTRONICS?

According to a recent report in the online journal *Advanced Materials*, researchers at Oregon State University (**http://oregonstate.edu**) have solved a mystery that has eluded scientists since the 1960s, leading to the possibility of an entirely new approach to electronics. The discovery involves the creation of a high performance "metal-insulator-metal" (MIM) diode. According to Douglas Keszler, a chemistry prof at OSU, "This is a fundamental change in the way you could produce electronic products, at high speed on a huge scale, at very low cost, even less than with conventional methods. It's a basic way to eliminate the current speed limitations of electrons that have to move through materials."

■ Asymmetric MIM diode developed at Oregon State University.



Today's silicon-based electronics work with transistors that control electron flow which is limited by the speed with which electrons can move through the materials. A MIM diode, in which an insulator is sandwiched between two layers of metal performs the same function in a different and much faster manner. In this device, "the electron doesn't so much move through the materials as it 'tunnels' through the insulator almost instantaneously appearing on the other side." A patent application has been filed for the new technology which may offer a way to "simply print electronics on a huge size scale even less expensively than we can now. And when the products begin to emerge, the increase in speed of operation could be enormous." ▲

COMPUTERS AND NETWORKING

CHINA BECOMES SUPERCOMPUTER TOP DOG

■ The Tianhe-1 supercomputer — clocking in at 2.507 PFlops/s — is now the world's fastest supercomputer.

Until recently, the world's fastest supercomputer was the Cray XT5 Jaguar system at Tennessee's Oak Ridge National Laboratory, with a speed of 1.76 PFlops/s. It appears now that China's Tianhe-1 (Chinese for "Milky Way") has smashed the record with a sustained computing speed of 2.507 PFlops/s. According to the developer — the National University of Defense Technology — the achievement comes from upgrading the Intel and NVIDIA processors, and the installation of some domestically produced FeiTeng-1000 CPUs.

Specifics weren't offered, but before the upgrade, the 155 ton machine reportedly used 14,336 Intel Xeon CPUs and 7,168 NVIDIA Tesla GPUs (each with 448 cores). It has a theoretical top speed of 4.7 PFlops/s. According to Liu Guangming, director of the National Center for Supercomputing in Tianjin, Tianhe-1 has begun trial use with clients that include the Tianjin Meteorological Bureau and the National Offshore Oil Corporation. "It can also serve the animation industry and bio-medical research," he noted. ▲

NEXT-GENERATION GRAPHICS PROCESSOR FOR CONSUMER DEVICES

Coming to a range of consumer products soon is ARM's fourth-generation Mali™ GPU, said to deliver five times the performance of the current Mali processors. According to ARM, "The debut of the scalable, multicore Mali-T604 GPU raises the performance bar for visual computing in the consumer electronics space, including mobiles, tablets, DTVs, and automotive infotainment. The tri-pipe innovative graphics architecture within the Mali-T604 GPU addresses the computationally intensive demand inherent in next-generation interactive user interfaces and gaming."

The unit is designed to meet the needs of General Purpose computing on GPU (GPGPU) and extends API support to include Khronos™ OpenCL™ and Microsoft® DirectX®. GPGPU support is noted to be increasingly important for enhanced Augmented Reality applications and gesture recognition. The new Mali processor also reduces memory bandwidth consumption by up to 30 percent which improves energy efficiency. The GPU is available for license by ARM partners, and Samsung will be the first to embed it in its products. For details, visit **www.arm.com/products/multimedia**/. ▲

SOLAR-POWERED WIRELESS KEYBOARD

■ The solar-powered Logitech K750 wireless keyboard.

Demonstrating that there's more to keyboards than a bunch of keys, Logitech (**www.logitech.com**) has introduced what is probably its slickest keyboard yet. The K750 eliminates the need to change batteries by powering itself from ambient light, even indoors. According to the company, not only is it powered by light, but energy consumption is so low that it can work in total darkness for up to three months. (So, if you spend a lot of time typing in the dark, you're in luck.) In addition, the K750 is only 1/3 of an inch thick, and it features the company's concave Incurve keys™ which are designed to support the shape of your fingertips and help guide fingers to the right keys. The device operates with 2.4 GHz wireless connectivity and includes 128-bit AES encryption for added security. Suggested retail is $79.99. ▲

CIRCUITS AND DEVICES

NEW CAMERAS FOR MACHINE VISION

If you happen to be involved in manufacturing inspection, intelligent traffic systems, food inspection, or any field that makes use of high-speed color cameras, you may be interested in the new lineup from Ontario-based DALSA Corp. The new Genie HC series consists of the HC640 (up to 300 fps, 640 x 480 resolution), the HC1024 (117 fps, 1024 x 768), and the HC1400 (75 fps, 1400 x 1025). All comply with the Automated Imaging Association's GigE Vision standard for direct link to a PC, and they offer Gigabit Ethernet technology, transmitting data over standard CAT-5e and CAT-6 cables up to 100 m. The Genies come with the company's Sapera™ Essential and Genie Framework software packages,

■ A Genie high-speed color camera, designed for machine vision on the factory floor.

designed to provide fast and simple setup (said to take only a matter of minutes). Other features include a ruggedized RJ45 connector highly suitable for robotic applications, and 1000x anti-blooming, resulting from the company's proprietary CMOS technology. Information on these and the DALSA's full line of machine vision products can be found at **www.dalsa.com/mv**. ▲

■ DCC's HotSpot capacitive discharge welder for thermocouple fabrication.

DO IT YOURSELF THERMOCOUPLES

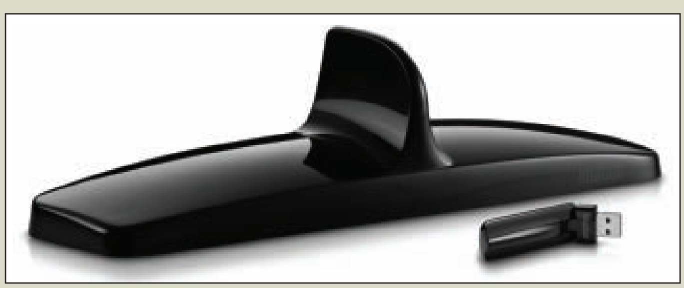
If you have ever said to yourself, "Boy, I sure wish I could fabricate my own thermocouples," DCC Corporation (**www.dcccorporation.com**) can make that wish come true. The HotSpot capacitive discharge welder is designed for just that purpose. The HotSpot generates an electric arc that fuses standard couple elements into freestanding beads and welds them to a base metal of any thickness. Stored weld energy ranges from 5 to 50 watt-seconds, and you can weld wire pairs up to #24 gauge at a rate of 5 to 10 welds per minute, depending on the energy setting. Power is provided from the AC power line via a step-down transformer, or from a gel-type battery that allows a few hundred welds without the AC connection. DCC says it's faster than gas welding and produces a more reliable contact mechanical twisting or clamping. Plus, the compact size (3.25 x 6 x 6.25 inches or 8.25 x 15.25 x 15.9 cm) and light weight (6.25 lb or 2.8 kg) make it highly portable. For only $689, you can join the list of 200+ current users, ranging from Abbott Labs to Zilog.

What? You say you've never wished for such a thing? Well, check out DCC's website anyway. Oddly enough, they also manufacture and sell some cool ultralight and experimental aircraft based on designs by Earthstar. You can pick one up as a kit or in ready-to-fly form. ▲

PC-TO-TV CONNECTION

The latest from Imation (**www.imation.com**) is the Link™ Wireless Audio/Video Extender which allows you to send both audio and high-def video content (including Internet TV, movies, photos, games, video-conferencing, business conferences, and so forth) to a television or projector using wireless USB technology. The Link works as a digital entertainment server, providing up to 720p video quality and 1080p for still images, along with two-channel audio. The PC- and Mac-compatible device uses a directional antenna to provide a line-of-sight range of up to 30 ft (9 m). The receiver connects to the TV set via an HDMI or VGA input, and the transmitter connects to any standard USB 2.0 port on a laptop or desktop. The only snag is that you need at least a 1.6 GHz processor, and a dual core is recommended. The unit lists for $149.99, but you can pick one up for about 10 percent less from various online stores. ▲

■ The Imation Link provides wireless connectivity between a PC and TV.



INDUSTRY AND THE PROFESSION

COGSIMA 2011 CONFERENCE SCHEDULED

On Feb. 22-24, the 2011 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support will be held at the Miami Beach Resort and Spa. If you don't even know what that means, don't worry. You're not alone. The conference is expected to draw only 140 attendees. But, so what? We're talking February and Miami Beach. Heated pool, deep-sea fishing, scuba, access to the Miami Beach Golf Club, and rooms starting at $79. Come to think of it, maybe you need to know more about cognitive methods. ▲

■ Forget the cold. You could be here.

INTEL INVESTING

Money is tight all over, but Intel is bucking the trend and has announced $6-8 billion in funding for future generations of manufacturing technology in American facilities. The gigabucks will underwrite next-generation 22 nm manufacturing technology among several existing factories, plus a new fab plant in Oregon. The projects are expected to support 6,000 to 8,000 construction jobs, and create up to 1,000 permanent high-tech positions.

"Intel makes approximately 10 billion transistors per second," said Brian Krzanich, senior VP and general manager. "Our factories produce the most advanced computer technology in the world, and these investments will create capacity for innovation we haven't yet imagined. Intel and the world of technology lie at the heart of this future. Contrary to conventional wisdom, we can retain a vibrant manufacturing economy here in the United States by focusing on the industries of the future."

Although Intel generates approximately three-fourths of its revenues overseas, it maintains three-fourths of its microprocessor manufacturing in the US. This new investment commitment will allow the company to maintain its manufacturing employment base at these sites. **NV**

■ BY JON WILLIAMS

FROM SPIN TO PASM AND BACK AGAIN!

For those of us that started with the BASIC Stamp and then (perhaps) migrated to the SX via SX/B, there can be a bit of a learning curve moving to the Propeller and its native language, Spin. Personally, I like programming in Spin and I think my exposure to other programming languages allowed me to pick it up and adopt it pretty quickly. Like anyone, though, it took a few programs before the "Aha!" moment revealed itself. In working with friends, I got the idea that sharing variables and the cog-to-cog connection is a real challenge. So, let's start the new year with a tutorial of sorts so that we can get a really firm grip on these processes. Once you have your own "Aha!" moment, a whole new world of programming fun opens up for you.

I know what you're thinking: "He mentioned PASM – man, I don't want to learn Assembly!" With the speed improvement of the Propeller over the BASIC Stamp, you don't have to for everything, but there will be times when using PASM over Spin is required, and other times when it would just be nice in terms of performance improvement.

For example: If you want to create a 1-Wire driver, it is my opinion that it must be done in PASM. The timing requirements of that protocol are very strict (it's asynchronous, so they have to be) and the ~5 microseconds time per Spin instruction is just too coarse. In the "nice to have" category, you can find floating point math objects in the Object Exchange (ObEx) that are written in Spin and PASM — the latter being much faster. In applications like real-time process control that require floating point math, speed is important and PASM is a big help. Thankfully, as with the floating point libraries, there are a lot of great PASM objects available for us to use.

There is no person in their right mind that would accuse me of being the brightest bulb in the box and yet I have been able to write PASM code for many applications. I find PASM far friendlier than other flavors of Assembly and am getting better all the time. You will, too — once you dig in.

That said, I'm getting ahead of myself, and this article is not about PASM programming but how to share variables in a complex project, such as how to connect Spin code to PASM code when that need arises. Again, this seems to be a stumbling point for many Propeller newcomers and it is my hope to put a "regular guy" spin (pun intended) on the process to help you create cooler Propeller programs. As with many programming languages, Spin has features that protect the casual programmer, while giving the advanced programmer the tools for creating code as he or she desires.

SCOPING THINGS OUT

Before we get to the Spin-to-PASM connection, it's probably a good idea to talk about variable scope as this will answer the "Why do we have to do it that way?" question before we get there.

Let's start with a very simple program; this will print a random number of stars (asterisk character) on a terminal every 500 mS:

```
obj

  term : "fullduplexserial"


var

  long  stars


pub main | lottery, idx

  term.start(RX1, TX1, %0000, 115_200)
  pause(1)
  term.tx(CLS)
```

```
  repeat
    ?lottery
    idx := ||lottery // 32 + 1
    printstars(idx)
    pause(500)


pub printstars(count)

  if (count > 0) and (count =< 32)
    repeat count
      term.tx("*")
    term.tx(CR)
```

Starting from the top, we can see that this object — our top object — has a child object called ***term*** that is of a FullDuplexSerial type. Let's skip past this for a moment and come back to it.

In the **VAR** declaration section, we have a long called *stars*. Variables declared in the **VAR** section are global to the object; that is to say that any of the methods in the object have access to them. While we're not doing it now, we could access *stars* from the **main()** method, as well as from the **printstars()** method.

In the **main()** method, we have two local variables: *lottery* and *idx*. The only code that has direct access to these variables is in **main()**. If I wrote a line of code in **printstars()** that attempted to use *lottery* or *idx*, the compiler would complain. This is what we mean by scope: it refers to the access of a variable. Some variables have global scope, some are local. On the storage side, all variables for Spin code are stored within the 32K hub RAM; it is the compiler that prevents local variables in one method from being [directly] accessed by another method.

In Spin, local variables can have the same name as local variables in other methods; the local scope prevents conflicts. What we cannot do is give a local variable the same name as a global variable in the object as this would create a conflict for the compiler. I try to give most variables unique names but as in this case, there are generic names I use for local variables that have meaning to me. For example, *lottery* for random numbers and *idx* for an array index or generic counter.

At the top of the our listing, we declared an object called ***term*** that will handle serial communications to a terminal program. If we open that object, we'll see that it also has a global **VAR** section. With these variables defined in a **VAR** section, do we have access to them from our top object in the **main()** and **printstars()** methods? No. As I stated earlier, global variables are only global to the object in which they are defined. A child object usually provides access to its variables through custom methods. The benefit of this strategy is that a child object controls what it reveals to its parent.

It may seem a bit of a hassle to have to write a method to expose the value of a variable in the child object, but this is really for the best. Imagine if variables in a child object **VAR** section became global to a project in which the object is used. It's likely that we'd have all sorts of naming conflicts in the project, rendering the use of separate object files, well, useless.

A couple final notes vis-a-vis scope for child objects: A parent has access to those child methods that are declared as **pub**lic only. From time to time, we will create child object methods that should only be called from within that object. In these cases, we should declare the method as **pri**vate. Finally, child objects do not have access to methods in their parent.

WHAT'S YOUR ADDRESS, MAN?

I have deliberately used the term "direct access" a couple of times — let me explain why. As I indicated earlier, all Spin variables are stored in the hub RAM. It stands to reason, then, that we should be able to get to any variable from any piece of code. We can ... if we know that variable's address.

You may see code that looks like this:

```
pntr := @myVariable
```

The @ symbol tells the compiler to move the *address* of *myVariable* into *pntr*; without the @ symbol, we would copy the value in *myVariable* to *pntr*. This is tricky at first but really useful. If we know the address of a hub variable, we can get to it from anywhere — even from anther cog. To write a value to a known address, we could do this:

```
long[pntr] := someValue
```

This bit of code tells the compiler to write a long (four bytes) to the address stored in *pntr*. We can also write words and bytes. This technique allows objects to update variables in other objects, even when normal scope rules would prevent it.

Of course, we can also read a value this way:

```
someValue := long[pntr][2]
```

Knowing the base address, we can treat the hub RAM as an array, as shown above. In this particular example, the second word after the location indicated by *pntr* will be moved into *someValue*.

It should be clear that the key to allowing one method or object to access variables in another — even from another hub — is to share the address of the variable(s) you want to allow access to.

Let me give you a real-world example: I'm working on a pan/tilt controller for my buddy, Lou. The circuit includes an MCP3208 ADC chip. In Lou's project, I want the joysticks to be read every millisecond and automatically update an array that is part of the main program. The ADC object I'm working on (in PASM, hence runs in another cog) uses the following call to initialize:

```
analog.init(CS, CLK, DIO, @joysticks)
```

The first three parameters are the pins used by the

ADC chip. Note that the forth is prefixed with @ which indicates I want to pass the address of the array called *joysticks*. The PASM code will use the **wrword** instruction to write a word variable to a hub location; knowing the hub address of *joysticks*[0] lets me update the array.

What I hope you grasp by now is that if a variable lives in the hub RAM, we can get to it from anywhere, even a PASM cog. What we cannot do, however, is directly manipulate a PASM variable from another cog. Of course, we can indirectly manipulate a PASM variable — this requires a gateway to the cog and will be the focus of the rest of this article.

FROM SPIN TO PASM AND BACK

When dealing with a variable that's part of a PASM program, access to the variable from outside the cog requires some code. In general, the outside code passes a request to the cog through a known hub variable. The cog must read this request and respond as desired, which could be to write a value to some location in the hub that is known to the outside code.

Propeller newcomers — especially those with Assembly experience in another processor — often ask how to integrate PASM methods into their Spin programs. As with variable access in a PASM cog, we can't — at least not directly.

Keep in mind that our Spin code is running in a Spin interpreter (virtual machine is probably a better description) that has been loaded into a cog. A cog running the Spin interpreter can only run pre-compiled Spin byte codes (which are stored in the hub); there is no way to interleave straight PASM code into these programs. What we do, then, is create a PASM program and launch it into its own cog. To access this code, we create a Spin interface that allows values to move from Spin to PASM and back again.

I like creating templates for programs that will adopt a similar structure and I have one for creating subroutines in PASM. Of course, it requires a little bit of effort to take it from template to working program, but it handles a lot of the grunt work required to pass commands from Spin to PASM, and to get a result from PASM to Spin. You can find that code in ***__pasm_subs.spin*** (I use the double underscore to force it to the top of the file's pane in the Propeller Tool).

As learning by specific example is best, and blinking LEDs is something we can do with virtually any Propeller development setup, let's learn how to connect from Spin to PASM by creating a little LED control mechanism. Remember, we're not blinking LEDs for the sake of blinking LEDs, but to start to get comfortable connecting Spin to PASM. Once we're comfortable with the connection, the sky is the limit!

Okay, we can't get there without knowing where we're going, so let's make some decisions:

1) We'll have a command that allows us to turn an LED on or off.
2) We'll have another command that lets us blink an LED a specific number of times — we can also specify the blink timing (ms).

The fully commented blinker object is ***led_ctrl.spin***. Let's dissect it — though not in order as we find in the listing — to get a handle on how it works.

At the top are the variables that are global to the object:

```
var

  long  cog

  long  mstix
  long  cmd
  long  pin
  long  pulses
  long  timing
```

The first variable, *cog*, is used to indicate that the PASM cog is loaded. The way in which this variable is used is very standard in PASM objects created by Parallax and others.

The next group is what we're going to be working with. The first, *mstix*, holds the number of counter ticks per millisecond. We need this for delays, and this really should be set at run-time to account for the speed at which the Propeller is running. *Cmd* will hold the command passed to the PASM code, and also serves as a flag to indicate when an external process is finished. *Pin* is the pin number we want to use. *Pulses* will hold the pulse count for that feature. It is also used to hold the state for direct on/off control. Finally, *timing* will hold the pulse timing in milliseconds for that feature.

As with other PASM objects, we need to launch the code into its own cog. Some objects use a method called **start()**, though I prefer to use **init()** as this prevents confusion with I^2C commands that are often used with the Propeller. For this program, we don't have to pass any parameters to the **init()** method:

```
pub init | ok

  finalize

  mstix := clkfreq / 1_000
  cmd   := 0

  ok := cog := cognew(@entry, @mstix) + 1

  return ok
```

The first thing we need to do is make sure that our object doesn't already have a cog loaded and running. If it does, the **finalize()** method will shut it down.

Initialization is pretty simple: We set the number of counter ticks per millisecond in *mstix*, clear the command (so that the PASM cog will wait for a valid command), and then we start the cog. Note that in the **cognew** instruction we pass the address (@) of the code that will be loaded, as well as the address of *mstix* which is the first in our list of working variables.

There was a recent post in the Propeller forum that

the interface to a PASM-coded object should be through a single variable (usually a variable address) which is passed in the *par* register (the second parameter in the **cognew** call). In the past, I have violated this idea by allowing Spin to "poke" values into the Assembly code before it is launched into its own cog. There is a good reason for the *par* only access: this allows creators of other languages to adapt our PASM objects. This is a good thing as it allows our hard work (the PASM code) to be used by more programmers.

Let's skip down to the top part of the Assembly code for our object. This provides the connection to the variables we've established above:

```
dat

                    org      0

entry               mov      tmp1, par
                    rdlong   ms001, tmp1
                    add      tmp1, #4
                    mov      cmdpntr, tmp1
                    add      tmp1, #4
                    mov      pinpntr, tmp1
                    add      tmp1, #4
                    mov      pulsepntr, tmp1
                    add      tmp1, #4
                    mov      timepntr, tmp1
```

As a reminder, when we launch the Assembly code into its own cog we pass the address of *mstix* in the *par* register. As *mstix* is the first in our list of object variables, we can use it as an anchor point.

The PASM code starts by copying *par* into *tmp1* so we can modify it to point to the other variables. *Tmp1* now holds the address of *mstix* so we use this with **rdlong** to move the number of ticks per milliseconds into the cog variable, *ms001*. Yes, the cog does have access to the **clkfreq** register but without built-in division, it's easier to do the ticks-per-millisecond math in Spin.

If we add four to what's in *tmp1,* we'll have the hub address of the object variable called *cmd*, the next variable in our list. This gets saved into a PASM variable called *cmdpntr*. This same process is used to save the hub addresses for the pin, blink count, and blink timing variables. With the variable pointers set up, the next part of our PASM code will wait on and process a command from the hub:

```
getcmd              rdlong   tmp1, cmdpntr wz
          if_z      jmp      #getcmd

checkcmd            cmp      tmp1, #1       wz
          if_e      jmp      #cmdset
                    cmp      tmp1, #2       wz
          if_e      jmp      #cmdblink

cmddone             mov      tmp1, #0
                    wrlong   tmp1, cmdpntr
                    jmp      #getcmd
```

If you're new to PASM, this is the equivalent of a stacked IF-THEN structure to process the command. The first line reads the long at *cmdpntr* into *tmp1*. Note that the Z flag is affected by this instruction. If the command is zero (no command), the Z flag will be set and the next line will cause the program to jump right back to the top to read the command again. This causes the program to wait for a non-zero command value.

At the label **checkcmd**, we start looking at the value passed by the user and dealing with it. There are many ways to do this and I tend to resort to simple. The **cmp** instruction compares what is now in *tmp1* with a legal command value. I prefer this style because it is, in fact, simple and allows the use of non-contiguous command values. When the command is equal to the value we're checking for, the Z flag will be set (**wz** must be specified with **cmp** to set/clear the Z flag). The **if_e** (if equal) condition — when true — causes the program to jump to the appropriate command handler code. If the command passed is not known by the program, the code eventually makes it to **cmddone** where the hub variable is overwritten with zero. This allows another command. We use the same process (clear to zero) at the end of valid commands.

Back to the Spin code. Let's look at the Spin interface for controlling an LED (turning it on or off):

```
pub set(p, state)

  repeat while (cmd <> 0)
  pulses := state
  pin := p
  cmd := 1
```

Notice that the first line of code in this method actually checks to see if the PASM cog is busy by looking at the present hub value of *cmd*. This will be important in many applications, especially when the background process is somewhat involved (e.g., transmitting an IR code or other signal generation). The next step is to load up the variables used and as you can see, we're doing it in reverse order. This part is really important. Since the top of the PASM code is just waiting for *cmd* to change to a non-zero value, we have to load any variables required by the background process first.

When the **set()** method is called, the following (super duper easy) PASM code is executed:

```
cmdset              rdlong   tmp1, pinpntr
                    mov      pinmask, #1
                    shl      pinmask, tmp1
                    rdlong   tmp1, pulsepntr
                    test     tmp1, #1         wc
          if_c      or       outa, pinmask
          if_nc     andn     outa, pinmask
                    or       dira, pinmask

                    jmp      #cmddone
```

To activate a pin, we need to know what the pin number is and the state we want to set it to. We read the pin number from the hub (stored at the address in *pinpntr*) into *tmp1* and then use that to create a pin mask. We're going to read the desired state (0 for off, 1 for on) from BIT0 of the value stored at *pulsepntr*.

To check the state, we use the **test** instruction with a mask value of 1 (BIT0 only). The **test** instruction works like

and but doesn't affect the value in the destination field (*tmp1* in this case). What it will do, though, is affect flags at our direction. As we've specified modifying the C flag in the **test** instruction, the C flag will receive the desired LED state.

Using conditional instructions with the C flag, we can write a "1" to the **outa** bit for the pin when it's supposed to be on (high) or zero when it's off (low). If you're brand new to PASM, you may be wondering what happens when a condition is false. That instruction simply acts like a **nop** and does nothing (except consume one instruction cycle). By using **or** with the pin mask, we can write a "1" to the desired bit without affecting the others; by using **andn**, we can write a "0" to the desired bit without affecting the others. Note that in either case we always write a "1" to the pin's bit in the **dira** register to make it an output.

Now, if a program was doing a calculation or waiting to get a value back from an external device, we would write the result back to the hub at a location known by the Spin interface. Once the result — if there is one — has been written to the hub, we can clear the command value and allow another to be passed. As in the Spin interface, the command variable in the hub is the last thing to be modified.

You should be able to analyze and understand the command for blinking an LED (cmd = 2) with no trouble now. Remember to download the commented listing from *Nuts & Volts* website. It includes a demo code that puts the object through its paces and will allow you to experiment.

IT'S A NEW YEAR, IT'S TIME TO PLAY!

I know, I know, blinking LEDs is boring. (For me, too, believe me.) But so is going to the gym and lifting weights to get trim and healthy, yet most of us do it. I ask you to be kind to yourself and play with this program until the interface makes sense and you can make it bend to your will. We're going to do some really fun projects this year and I want you to be able to modify them as your needs differ from mine. For that to happen, though, you need this foundation. Okay? Okay. Go have fun!

Until next time, keep spinning and winning with the Propeller! **NV**

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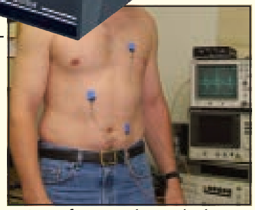
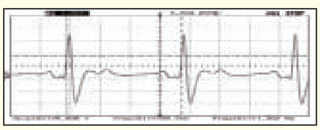
Well, it's another New Year, and there no better time for that ultimate resolution… taking better care of yourself. And there's no better way to do that then to be "heart smart" with our ECG1C Electrocardiogram Heart Monitor! Not only will building an actual ECG be a thrill, but you'll get hands-on knowledge of the relationship between electrical activity and the human body. Each time the human heart beats, the heart muscle causes small electrical changes across your skin. By monitoring and amplifying these changes, the ECG1C detects the heartbeat and allows you to accurately display it, and hear it, giving you a window into the inner workings of the human heart and body!



One of our engineers/guinea pigs, checking his heart!

Use the ECG1C to astound your physician with your knowledge of ECG/EKG systems. Enjoy learning about the inner workings of the heart while, at the same time, covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors.

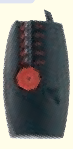


The documentation with the ECG1C covers everything from the circuit description of the kit to the circuit description of the heart! Multiple "beat" indicators include a bright front panel LED that flashes with the actions of the heart along with an adjustable level audio speaker output that supports both mono and stereo hook-ups. In addition a monitor output is provided to connect to any standard oscilloscope to view the traditional style ECG/EKG waveforms just like you see in a reall ER or on one of the medical TV shows! See the display above? That's one of our engineers, hooked up to the ECG1C after an engineering meeting! (We were all surprised it wasn't flat lined!)

The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading and display every time! 10 hospital grade re-usable probe patches are included together with the matching custom case set shown. Additional patches are available in 10-packs. Operates on a standard 9VDC battery (not included) for safe and simple operation. Note, while the ECG1C professionally monitors and displays your heart rhythms and functions, it is intended for hobbyist usage only. If you experience any cardiac symptoms, seek proper medical help immediately!

ECG1C	**Electrocardiogram Heart Monitor Kit With Case & Patches**	**$44.95**
ECG1WT	**Electrocardiogram Heart Monitor, Factory Assembled & Tested**	**$89.95**
ECGP10	**Electrocardiogram Re-Usable Probe Patches, 10-Pack**	**$7.95**

Pocket Audio Generator



A perfect test source for stereo line inputs on any amplifier or mixer. Provides 50Hz, 100Hz, 1kHz, 10kHz, & 20kHz tones, plus 32 bit digital pink noise. Great to help you identify cables or left/right reversals! Stereo RCA line level outputs. Uses 2xCR2025, not included.

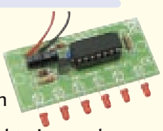
K8065 Pocket Audio Generator Kit $29.95

Pocket Vu Meter

Hand held audio level meter that fits in your pocket! Built-in mic picks up music and audio and displays it on an LED bargraph. Includes enclosure shown. Runs on one 3V Li-Ion button cell, not included. If you ever wanted an easy way to measure audio levels, this is it!

MK146 Pocket Vu Meter Kit $8.95

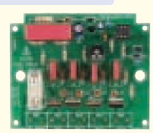
Mini LED Light Chaser



This little kit flashes six high intensity LEDs sequentially in order. Just like the K8032 to the right does with incandescent lights. Makes a great mini attention getter for signs, model trains, and even RC cars. Runs on a standard 9V battery.

MK173 Mini LED Light Chaser Kit $15.95

Running Light Controller



Controls and powers 4 incandescent lights so they appear to "travel" back and forth (Like the hood on KITT!). Great for the dance floor or promotional material attention getters, exhibits, or shows. Runs on 112-240VAC.

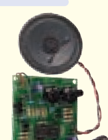
K8032 4-Channel Running Light Kit $38.95

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.

MK171 Voice Changer Kit $14.95

Steam Engine & Whistle



Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.

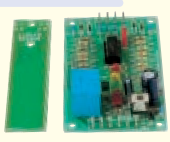
MK134 Steam Engine & Whistle Kit $11.95

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1 Laser Trip Sensor Alarm Kit $29.95

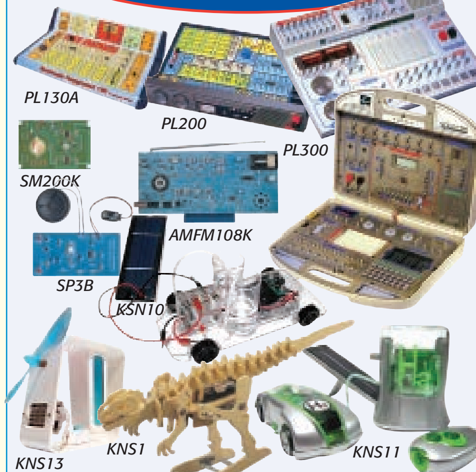
Liquid Level Controller



Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.

K2639 Liquid Level Controller Kit $21.95

The Learning Center!



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Vintage Battery Eliminator

Collectors come across some great deals on antique battery-powered radios, but how to power them is a real problem. Many classic radios operated on batteries only, and in many cases a series of three batteries for each radio were required!

The new ABCE1 Battery Eliminator gives you an easy way to replace all these batteries with a simple household AC power connection and resurrect your vintage antique radios! Provides "A" filiment, "B" plate, and "C" control grid supplies, which are all isolated from each other. Complete with aluminum case. Runs on 110-240VAC.

ABCE1 — Vintage Radio Battery Elim Kit — $199.95

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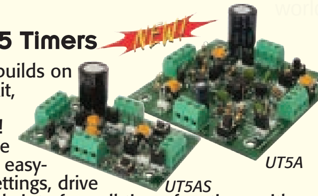
The third generation of Ramsey digital voice storage kits! We started with the latest digital voice storage technology. It provides up to 8 minutes of digital storage at a frequency response up to 3.5 KHz. (Total message time and frequency response is dependant on selected internal sampling rate.) Once recorded, messages are available for playback on-demand or automatic continuous looping. Standard RCA unbalanced line level output is provided for easy connection to any amplifier, amplified speaker, mixer, or sound system. In addition, a standard 4-8 ohm speaker output is provided to directly drive a monitor speaker. Can be remote controlled via 3-wire BCD with our interface options. Check www.ramseykits.com for all options!

DVMS8 — Digital Voice Message 8Ch Kit — $99.95
DVMS8WT — Assembled DVMS8 — $149.95

Ultimate 555 Timers



This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

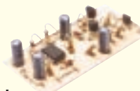
UT5A — Through Hole 555 Timer/Osc Kit — $24.95
UT5AS — SMT 555 Timer/Osc Kit — $26.95

Passive Aircraft Monitor

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 — Passive Aircraft Receiver Kit — $89.95

Voice Activated Switch



Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.

VS1 — Voice Switch Kit — $9.95

OBDII *CarChip Pro*

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 — CarChip Pro OBDII Monitor-Asmb — $99.95

RF Preamplifier

The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 — RF Preamp Kit — $19.95

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 — Touch Switch Kit — $9.95

Doppler Direction Finder

Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.

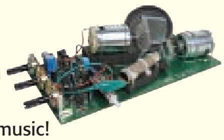
DDF1 — Doppler Direction Finder Kit — $169.95

Mad Blaster Warble Alarm

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

MB1 — Mad Blaster Warble Alarm Kit — $9.95

Laser Light Show



Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

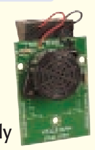
LLS1 — Laser Light Show Kit — $49.95

Retro Nixie Tube Clock

Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Tube kits also available.

IN14TM — Teak Maple Nixie Clock Kit — $329.95

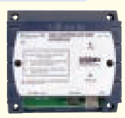
Water Sensor Alarm



This little $7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.

MK108 — Water Sensor Alarm Kit — $6.95

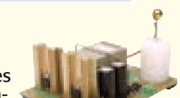
USB DMX Interface



Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.

K8062 — USB DMX Interface Controller Kit — $67.95

HV Plasma Generator



Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

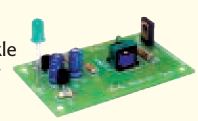
PG13 — HV Plasma Generator Kit — $64.95

Air Blasting Ion Generator

Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 — Ion Generator Kit — $64.95

Tickle-Stick Shocker



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 — Tickle Stick Kit — $12.95

Speedy Speed Radar Gun

Our famous *Speedy* radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.

SG7 — Speed Radar Gun Kit — $69.95

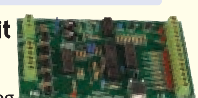
Tri-Field Meter Kit

THE GHOST DETECTOR!

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C — Tri-Field Meter Kit — $74.95

USB Experimenter's Kit



Get hands-on experience developing USB interfaces! 5 digital inputs, 8 digital outputs, 2 analog I/O's! Includes diagnostic software and DLL for use with Windows based systems. The mystery is solved with this kit!

K8055 — USB Experimenter's Kit — $49.95

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

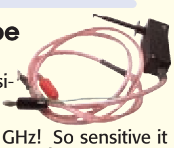
PR2 — Broadband RF Preamp — $69.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

MC1 — Mini Electret Condenser Mic Kit — $3.95

Sniff-It RF Detector Probe



Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!

RF1 — Sniff-It RF Detector Probe Kit — $27.95

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!

LAB1U — 3-In1 Multifunction Solder Lab — $134.95

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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✔ Cat 5 Cable Tester
- ✔ Low Battery Circuit
- ✔ Model Railroad Sequencer

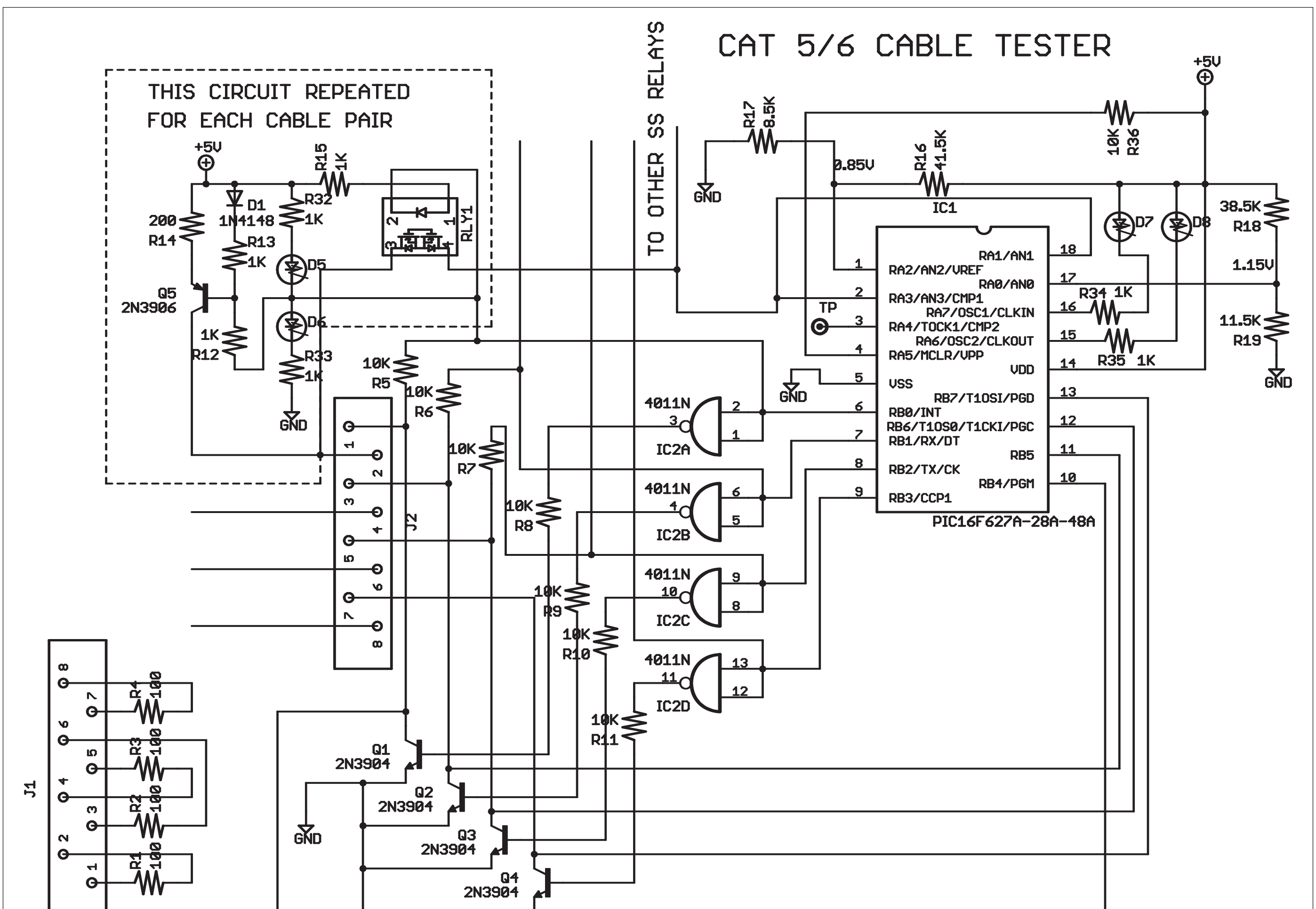
■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to: Q&A@nutsvolts.com**

CAT 5 CABLE TESTER

Q I do quite a bit of CAT-5/6 cable installations for telephone and data networks. Although I teach my crew to be very careful when attaching a RJ-45 plug or jack, invariably we end up with a few cables with crossed, open, or shorted circuits.

There are quite a number of LAN/telephone circuit testers on the market which are able to identify which pair or wire is shorted, crossed, or open, but the biggest problem and time waster is knowing which "end" needs to be fixed. One of Murphy's Laws states that we will spend 20 minutes going to and inspecting the wrong end. Sometimes it's so difficult to ID the conductor colors in a plug that we end up cutting off and



■ FIGURE 1

reconnecting both ends. Sometimes the mistake even gets repeated.

No one seems to make a tester that can ID which end of the cable needs fixing. It seems to me that a circuit tester with a little more processing power and smarts could also determine if, say, wire 1 is on pin 1 at end "A" but on pin 2 at end "B."

Yes, there are considerations for "cross-over" and data "A"/"B" circuit connections, but most good technicians know how to keep that in perspective for the type of circuit being connected and tested.

A CAT-5/6 cable tester to ID the miswired end would sure be welcomed and a very worthwhile project to build. Any help would be greatly appreciated.

— Vonn Hockenberger

A You would need a time delay reflectometer to determine which end has the error; if there is no time delay, the problem is at the transmitter end. Even if tests show that pin 1 of end A connects to pin 1 of end B, etc., it could be that wire 1 of pair 2 has been swapped with wire 1 of pair 3 on both ends. The nominal impedance of 100 ohms will be off for pair 2 and pair 3, so that has to be checked. Short circuits are most likely to occur between adjacent pins but if a microprocessor is used, it is just as easy to check every pin.

I was intrigued by the problem of a comprehensive cable test, so I came up with the schematic in **Figure 1**. There are two tests: a short test where the microcontroller makes RB0 (pin 6) high and the other three (RB1, RB2, RB3) low. Q2, Q3, and Q4 are turned on making those three cable pairs low. If either pin 1 or pin 2 of J2 or J1 is shorted to one of the low pairs, the collector of Q1 will be low even though it is not turned on and the connection to RB4 will register a failed test. This test will not detect a short between pins 1 and 2, but that will be checked in the next test.

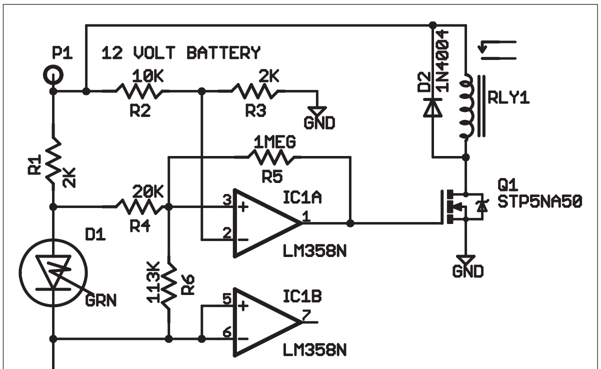
The second test is a load test where RB0 is made low and RB1, RB2, and RB3 are high. Q5 and Q1 are turned on and the transistors in the other cable pairs are turned off. The Q5 circuit is a constant current of 10 mA driving pin 2 of J2. This will develop one volt across R1 in the receiving termination which is fed through RLY1 to a window comparator at pins 2 and 10 of IC1. Pins 1 and 17 of IC1 are the other comparator inputs which are biased at 0.85 and 1.15 volts, respectively. If the signal is between 0.85 and 1.15, both comparator outputs are low and the test is good. If the signal is above 1.15 (open circuit), D8 is turned on; if the signal is below 0.85 (short circuit), D7 is turned on. The test stops when a failure occurs so you can see if it was a load test (D5 lighted) or a short test (D6 lighted). If I can make it work, I plan to have a continue button so the operator can check for more faults.

```
'*****************************************************************
'*  Name    : CAT 5/6 CABLE TESTER                               *
'*  Author  : RUSS KINCAID                                       *
'*  Notice  : KINCAID ENGINEERING                                *
'*  Date    : 10/20/2010                                         *
'*  Version : 1.0                                                *
'*  Notes   : TWO TESTS ARE DONE: A SHORT TEST AND A LOAD TEST   *
'*          :                                                    *
'*****************************************************************
     REM DEVICE = 16F627A
     TRISA = %00101111      '1 = INPUT, 0 = OUTPUT FOR PORT A
     REM RA4 IS UNUSED, SET AS OUTPUT. RA5 IS INPUT ONLY BY DESIGN
     TRISB = %11110000      '1 = INPUT, 0 = OUTPUT FOR PORT B
     CMCON = %0100          'COMPARATORS SET AS TWO INDEPENDENT
     REM THE INTERNAL VOLTAGE REFERENCE IS NOT USED
SHORT_TEST:
     PORTB = 1              'SETS RB0 HIGH, RB1-3 LOW
     IF PORTB.4 = 1 THEN GOTO SHORT2
     IF PORTB.4 = 0 THEN LOW PORTA.7        'SHORT INDICATION
     GOSUB WAITF
SHORT2:

     PORTB = 2              'SETS RB1 HIGH, RB0,2&3 LOW
     HIGH PORTA.7           'RESET THE FAULT LED
     IF PORTB.5 = 1 THEN GOTO SHORT3
     IF PORTB.5 = 0 THEN LOW PORTA.7        'SHORT INDICATION
     GOSUB WAITF
SHORT3:

     PORTB = 4              'SETS RB2 HIGH, RB0, 1&3 LOW
     HIGH PORTA.7
     IF PORTB.6 = 1 THEN GOTO LOAD TEST
     IF PORTB.6 = 0 THEN LOW PORTA.7        'SHORT INDICATION
     REM CABLE PAIR 4 WAS TESTED AGAINST ALL OTHERS PREVIOUSLY
     GOSUB WAITF
LOAD_TEST:

     PORTB = 14             'SETS RB0 LOW, OTHERS HIGH
     HIGH PORTA.7
     PAUSE 10               'TIME FOR COMPARATORS TO SETTLE
     IF CMCON.6=0 AND CMCON.7=0 THEN GOTO PAIR2
     IF CMCON.6=1 OR CMCON.7=1 THEN GOSUB CHECK
PAIR2:
     PORTB = 13             'SETS RB1 LOW, OTHERS HIGH
     PAUSE 10
     IF CMCON.6=0 AND CMCON.7=0 THEN GOTO PAIR3
     IF CMCON.6=1 OR CMCON.7=1 THEN GOSUB CHECK
PAIR3:
     PORTB = 11             'SETS RB2 LOW, OTHERS HIGH
     PAUSE 10
     IF CMCON.6=0 AND CMCON.7=0 THEN GOTO PAIR4
     IF CMCON.6=1 OR CMCON.7=1 THEN GOSUB CHECK
PAIR4:
     PORTB = 7              'SETS RB3 LOW, OTHERS HIGH
     PAUSE 10
     IF CMCON.6=0 AND CMCON.7=0 THEN END
     IF CMCON.6=1 OR CMCON.7=1 THEN GOSUB CHECK
     PORTB = 0
     HIGH PORTA.6
     HIGH PORTA.7
     STOP           'TURN OFF FAULT LEDS, END OF TEST
CHECK:
     IF CMCON.6 = 1 THEN LOW PORTA.6   'OPEN CIRCUIT
     IF CMCON.7 = 1 THEN LOW PORTA.7   'SHORT CIRCUIT
     GOSUB WAITF
     HIGH PORTA.7
     HIGH PORTA.6   'RESET THE FAULT LEDs FOR THE NEXT TEST
     RETURN
WAITF:
     WHILE PORTA.5 = 1
     GOTO WAITF
     WEND
     WHILE PORTA.5 = 0
     GOTO WAITF     'DON'T PROCEED UNTIL THE FINGER IS OFF
     WEND           'THE BUTTON
     RETURN
     END
```

■ FIGURE 2

In the CAT specs, pins 1 and 2, 5 and 4, 3 and 6, 7 and 8 are pairs. I don't know why it is that way, but you have to be aware that when pair 3 and 6 is load tested, RB1 is set low and the circuit returns to pin 6 of J2. When pair 5 and 4 is load tested, RB2 is low and the circuit returns to pin 4 of J2.

The program is in **Figure 2** and is mostly self-



■ FIGURE 3

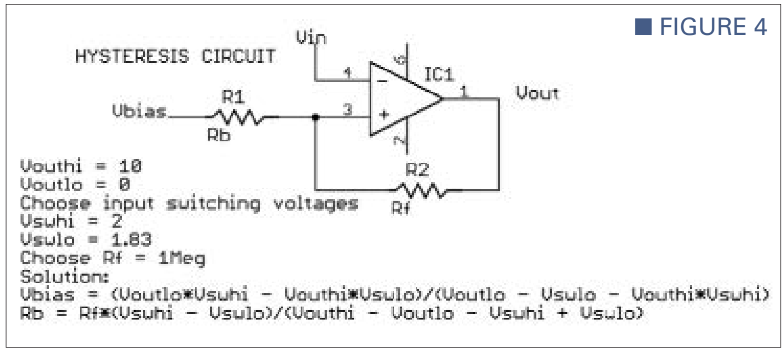
explanatory. I realize that I did not answer your question but I will think about a time delay reflectometer and perhaps have something in a later issue.

LOW BATTERY CIRCUIT

Q I am trying to design a low battery cutoff for a project that uses 12V SLA (sealed lead-acid) batteries. One of the items it is powering will drain the battery lower than the charger can recover. I need the unit to cut off output current when the battery reaches around 11 volts, then kick back on when the battery reaches 12V. I tried using simple SPDT relays, but the cut in/cut out voltage was too low. Cost and simplicity is a factor for this, as well. I'd also like this to be in a module form that I can bury inside the item, so I don't want to have any external switches or buttons if possible.

— Scott Bradford

A This circuit (**Figure 3**) has hysteresis such that it switches at 12V and 11V of the battery. Computation of the resistor values is a little complicated but straightforward: R1 supplies 5 mA to the green LED which is used as a voltage reference, assumed to be 2.2V. The voltage divider, R2, R3, represents the battery at Vd; when the battery is 11 volts, Vd = 1.83V, and by inspection, when the battery is 12 volts, Vd = 2V.



■ FIGURE 4

Now it is useful to simplify the circuit as in **Figure 4**. Rb is the parallel combination of R4, R6, and R5, but R5 is large enough to be neglected which simplifies the calculation of R4 and R6. Choose Rf to be one meg, then Rb = 17.3K and Vbias = 1.86V. Since the LED voltage is 2.2V, the voltage divider, R4, R6, is needed to get 1.86V. Now we have to solve two simultaneous equations in R4, R6:

R4*R6/(R4 + R6) = 17.3K and 2.2*R6/(R4 + R6) = 1.86

You can solve this with a BASIC program, or Eureka gives the solution: R4 = 20.46K, R6 = 111.94K. Standard 1% values that will work are 20K and 113K.

LED REPLACEMENT FOR AN INCANDESCENT LAMP

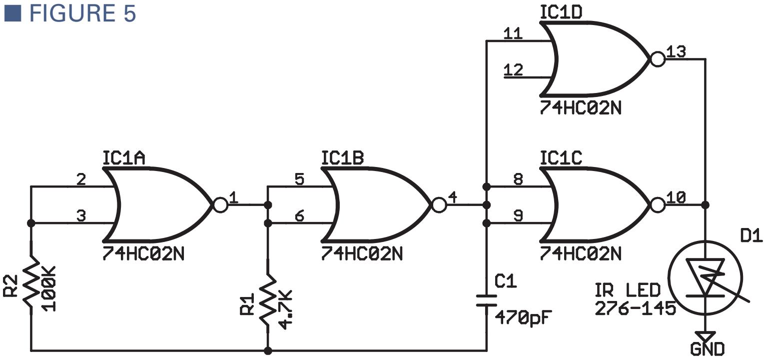
Q I want to replace an incandescent lamp with an LED. The lamp is obsolete. What it needs to do is send light in the 880 nm wavelength to a photo diode. I tried a lot of different IR LEDs but I'm still having trouble getting the LED light source to equal the incandescent lamp. I tried using LEDs from 20 mA to 100 mA, and it still doesn't work that great. I don't get the distance that I need; it needs to reach about two inches. Also, what about the viewing angle? Do I want more or less for longer distance? I'm guessing less because it would be more concentrated. The source voltage is 12V and the LED has a voltage drop of 1.8V at 100 mA DC.

My understanding is that you get more power by pulsing the LED than by using a constant source. Would that give me a greater distance? Any help will be appreciated.

— Jeff Miller

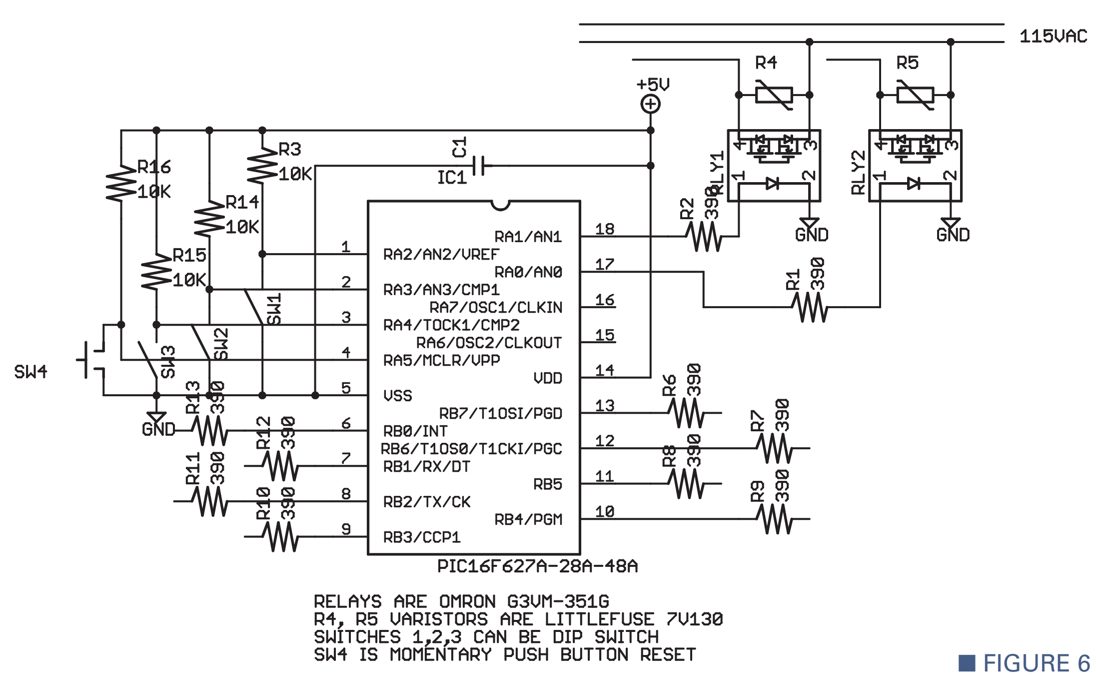
A Your system was designed to work with a constant incandescent source, so how it would respond to pulses is unknown. The LED can produce much higher peak power when pulsed, but the average power cannot exceed the DC rating of the device. Narrowing the beam angle does increase the power and you can do that optically.

You might be better advised to change the sensor to one that is compatible with the IR LED. Garage door systems work over a distance of 10 feet so two inches should not be a problem. I have had success with RadioShack components for a distance of six inches.

■ FIGURE 5


What do you know about the sensor? Do you know the part number? How many leads does it have? Is it in a TO-92 package or T-1 3/4 or other? If you install a 38 kHz IR receiver and pulse the LED at 38 kHz, two inches will be a piece of cake. RadioShack part number 276-640 is a three lead receiver (power, ground, and output). If your sensor is two leaded, you will need to find a source of 5 VDC to power the receiver. The metal standoff of the RadioShack receiver may have some heatsink function, so I would not cut it off but bend it out of the way and use a dab of silicone to mount the receiver.

The phototransistor (RadioShack 276-145) will plug right in the place of the photodiode. If that doesn't work, there is definitely a problem elsewhere in the receiving circuit. In that case, I recommend using the 276-640 IC receiver which has a logic level output. You will need a 38 kHz transmitter; see **Figure 5**.



■ FIGURE 6

MODEL RAILROAD SEQUENCER

Q Love your previous model railroad circuits. My layout has 10 amusement park rides; each powered with their own wall wart power supply. I would like to build a sequencer that would turn the rides on randomly ... like an actual amusement park. One, all, or none could be on at a time. The rides should run for a fixed period, like 10-15 seconds per period. Every circuit I think of does not produce random results. Any suggestions?

— Dominick Senna

A The BASIC language RANDOM command comes to mind which implies the use of a microcontroller. I don't know how to randomly change the output ports because they are not programmable. I could produce a random BCD code and use a one of 10 decoder, but that only turns on one at a time. Perhaps a loop that turns on different numbers of rides in a pseudo random fashion will work; see **Figure 6** and the program in **Figure 7** (I went through a number of more complicated programs before this one).

The schematic in **Figure 6** is partial; you will have a relay and varistor on all 10 outputs. The switches S1, S2, and S3 allow you to change the cycle time. The reset button is not needed; all it does is restart the sequence. I was surprised to see that even though port A uses only the low two bits, one or the other or both are always on. I had thought that even though the random process does not include zero, those two bits would be zero a lot of the time; not so. The relay is rated at 350 volts, 100 mA which should be adequate in the primary circuit. The varistor protects the relay from the inductive kick when it shuts off. **NV**

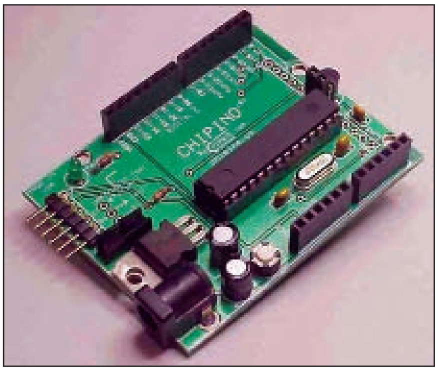
```
'***************************************************************
'*  Name    : MODEL TRAIN SEQUENCER                            *
'*  Author  : Russ Kincaid                                     *

'*  Date    : 10/26/2010                                       *
'*  Version : 1.0                                              *
'*  Notes   :THERE ARE 10 OUTPUTS, RANDOMLY SEQUENCED. THE TIME *
'*          :BETWEEN SEQUENCES IS PROGRAMABLE, 5, 10 ,15, OR 20 *
'*          :SECONDS.
'***************************************************************
        REM DEVICE = 16F627A
        CMCON = 7           'DISABLE ANALOG INPUTS
        TRISA = %00111100   'RA0, RA1 OUTPUT,RA6, RA7 OUTPUT OTHERS
INPUT
        TRISB = 0           'ALL OUTPUTS
    WAITE VAR WORD          'WAIT IS A RESERVED WORD, CAN'T BE A
VARIABLE
    SEQ VAR BYTE            'MAXIMUM VALUE IS 255
    A VAR BYTE
        START:
    WAITE = 5000             '5 SECONDS
    IF PORTA.0 = 0 THEN WAITE = 10000  '10 SECONDS
    IF PORTA.1 = 0 THEN WAITE = 15000   '15 SECONDS
    IF PORTA.2 = 0 THEN WAITE = 20000   '20 SECONDS

             RANDOM SEQ
             RANDOM A
             PORTB = SEQ
             PORTA = A
             PAUSE WAITE
             GOTO START
        END
```

■ FIGURE 7

NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

CHIPINO MODULE



The CHIPINO is a Microchip PIC-based module with the Arduino connection scheme. The CHIPINO — developed by the Chipaxe Team — **chipaxe.com** matches the board outline, mounting holes, connector spacing, and most of the microcontroller I/O functions found on the popular Arduino. The CHIPINO offers PIC users the opportunity to use existing compiler and programming tools with all the shields available to the open source world of Arduino.

The CHIPINO name comes from an Italian fishing town in San Francisco, CA, where fisherman were asked to "chip in" at the end of the day from their daily catch. The result was a community soup (Chipino soup) everyone could share. CHIPINO, does this same thing by offering an open source platform to build upon and then share application ideas. CHIPINO is programmed directly with an open sourced PICkit 2 or clone programmer. This programming method allows a user to plug any blank PIC16F or PIC18F 28-pin 0.300" pitch into it, and program in Assembly, BASIC, C, Pascal, Flowcode, or any other compiler that supports the PIC. The CHIPINO comes with a PIC16F886 along with the Microchip MPLAB IDE and the HI-TECH C compiler. You also get the Simple C library from Chuck Hellebuyck's future book *Beginner's Guide to Embedded C Programming Volume 3* that makes writing C programs as easy as BASIC or Arduino. The CHIPINO is offered as a bare board, a kit of parts, or as a fully assembled module. Pricing is $24.95 for a fully assembled module. Starter kits that include a PICkit 2 clone programmer are also available, along with a proto-shield that has a breadboard for building custom circuitry to interface to the CHIPINO.

For more information, contact:
CHIPAXE
Web: **www.chipaxe.com**
or **http://chipino.cc**

RESISTANCE/ CAPACITANCE DECADE BOX

The model RDB-10 from Global Specialties is a handheld resistance decade box that creates a specific resistance value using a combination of switches. Designed with accuracy to meet the needs of industry and education alike, the RDB-10 is a compact, convenient tool for aiding in engineering design and testing, as well as calibration of test equipment. It offers seven decades of resistance ranges, from 1 Ω to over 11 MΩ in one Ω steps. Easy-to-use slide switches allow for straightforward addition and subtraction of resistance values. RDB-10 is a passive device that requires no power source. The unit is housed in a rugged enclosure with an impact-resistant rubber boot.

The model CDB-10 is a handheld capacitance decade box that creates a specific capacitance value using a combination of switches. Also designed with accuracy for aiding in engineering design and testing, offers five decades of capacitance ranges, from 100 pF to over 11 µF in 100 pF steps. The CDB-10 has easy-to-use slide switches and the same rugged enclosure.

For more information, contact:
Global Specialties
Web:
www.globalspecialties.com

NEW ADDITIONS TO GEARBOXES

BaneBots announces new additions to their highly successful P60 family of gearboxes. In addition to the stock gearboxes,

literally thousands of custom configurations will be available starting in January. Despite their compact size, these gearboxes pack a lot into a small package. P60 gearboxes have been applied in an array of settings, including the educational, hobby, commercial, and industrial markets.

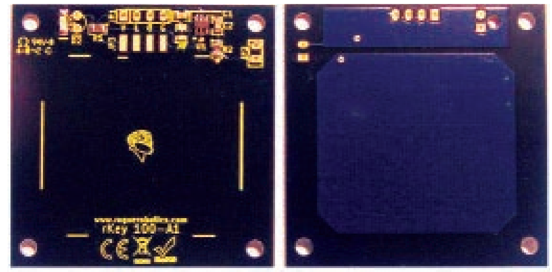
With a new total of 34 ratios — ranging from 3:1 to 672:1 — the gearboxes can be customized in a number of ways. Many of the new options are a result of customer feedback and requests. The P60 shafts will now be available in 3/8″ in addition to the original 1/2″ diameter, and a hex shaft has also been added to the line-up. Short, standard, and long shafts give users more flexibility in design.

New, multiple mounting patterns add to the diversity of applications and ease of use. BaneBots also has increased the range of motor support to include industry standard RS-380, RS-390, RS-395, RS-540, RS-550, and RS-775 sized motors, as well as popular hobby motors such as Speed 400 and rock crawler motors. Motors can be purchased either mounted or unmounted. Steel ring gear options give extra strength for those with more demanding operations, and the P60 gearboxes can be ordered greased or ungreased. In the near future, additional colors will be available for a customized look, as well. Another aspect of the P60 gearboxes is that they can be reconfigured to meet a customer's changing needs as a project evolves. If you own one P60, it is like owning several. BaneBots has all the gearbox parts available separately so that the ratios can be changed without purchasing a whole new gearbox.

The P60 has always been designed, manufactured, and assembled in the US at their Colorado facility. Components are CNC machined for tight tolerances and contain cold rolled steel gears and hardened 4140 steel carrier plates.

For more information, contact:
BaneBots
Web: **www.banebots.com**

rKEY™ ROBUST
CAPACITIVE SWITCH FOR INTERACTIVE DESIGNS



Rogue Robotics introduces the new rKEY™ capacitive switch product series. The rKEY capacitive switches allow OEM designers and hobbyists to quickly and easily add capacitive touch switches to their projects and products.

The rKEY capacitive switch series are compact (starting at 2″ by 2″ down to 1.25 x 1.25″) footprint boards, providing an easy-to-use non-mechanical touch switch for environmentally sealed environments and interactive displays such as music playback stations.

The capacitive switches are self-calibrating and extremely robust for harsh environments. The rKEY can be mounted behind various materials — plastics, wood, and glass — to a suggested maximum thickness of 0.4,″ and have an operating temperature range of −40C to +85C.

The rKEY-1.5 has a 1.5″ x 1.35″ key area and a 2″ x 2″ footprint; the rKEY-1.0 has a 1″ x 1″ key area and a 1.5″ x 1.5″ footprint; and the rKEY-.75 has a 1.35″ x1.25″ footprint. The rKEY switch (1.5″ x 1.35″) module retails for $11.99 (qty. 1) and $8.99 each (qty. 100).

For more information, contact:
Rogue Robotics
416-707-3745
Email: **sales@roguerobotics.com**
Web: **www.roguerobotics.com**

continued on page 49

By Norm Looper

EXPLORE ELECTRONIC CHAOS

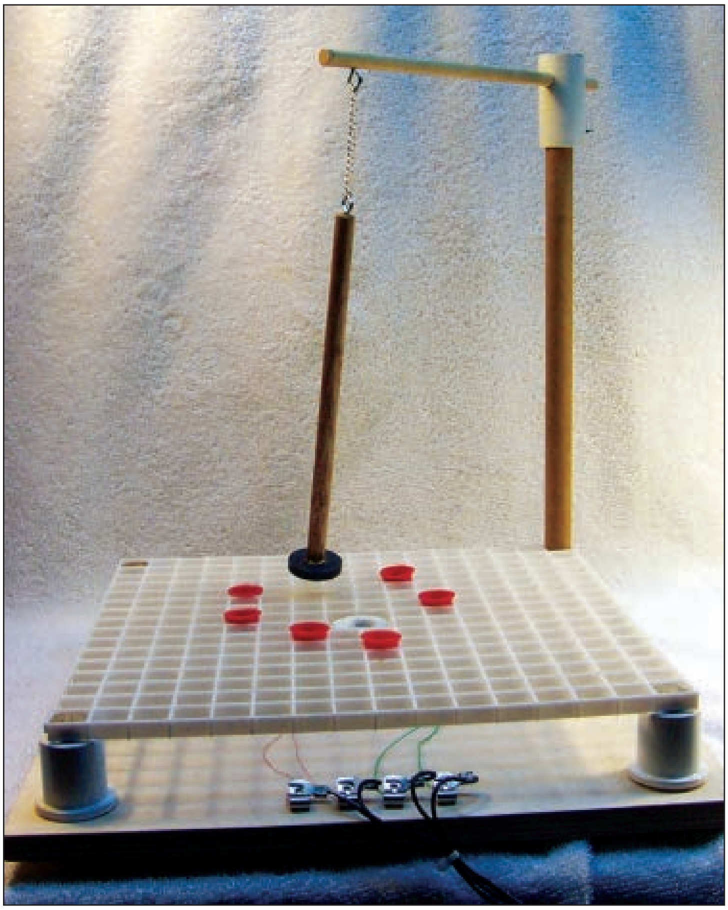
Chaos is best viewed as a form of "constrained randomness" and is all around us: bubbling cells of hot oatmeal; the colliding, rapid drips from a faucet; the unseen vortices of air tumbling off the back of your sedan; stable patches of commuter gridlock; and the movement of monetary "fluids" in distressed financial markets. Many times the governing relationships of these fluids will show domains where they can be chaotic, and fundamentally unpredictable.

A Simple Chaotic Oscillator You Can Build

You can build a simple, electronically-driven pendulum that can produce automatic, perpetual chaotic motions showing no discernable regularities. Nonetheless, this device (shown in **Figure 1**) has some residual order – but we can't see it readily when plotted against time. In a future article, we will explore how this kind of hidden order can be found and displayed.

How The Pendulum Works

Our chaotic pendulum consists of three subsystems: the mechanical pendulum itself, with a doughnut-shaped permanent magnet serving as the plumb bob, mounted on a wooden arm; a power supply that charges capacitors and powers the electronics; and the pendulum driver electronics. The driver electronics detect when the plumb bob is transiting a central electromagnet, and discharges the capacitors through this electromagnet to repel the plumb bob and sustain its motion. "Planetary" or satellite button magnets can be placed by the experimenter at a variety of different radii and angles relative to the central electromagnet to configure the general size and character of the plumb bob's chaotic motion.



■ FIGURE 1. The completed chaotic oscillator.

Electronic Operation

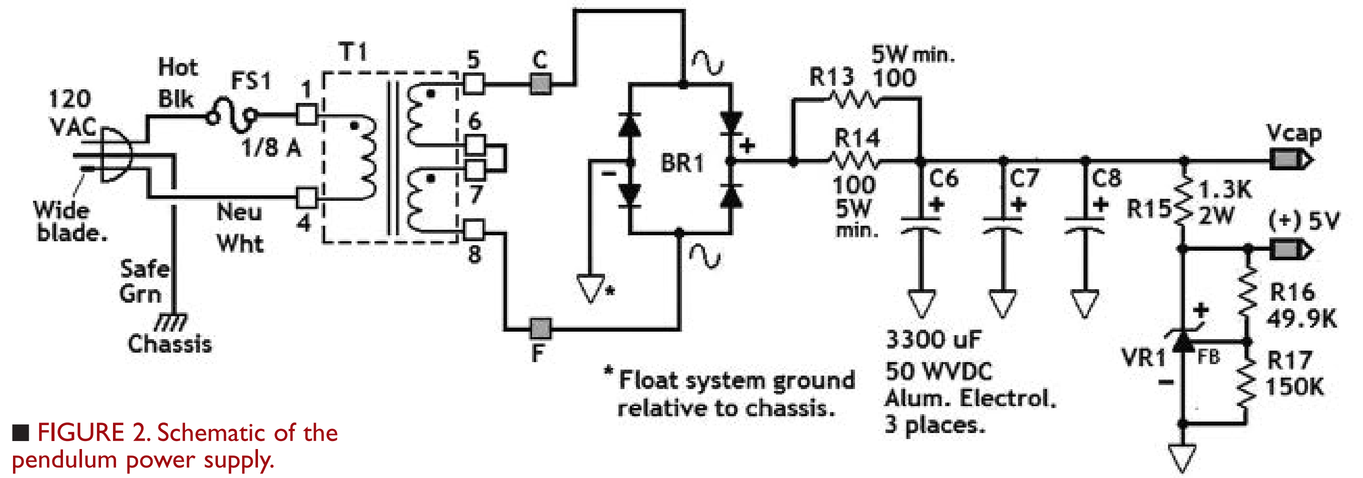
The Pendulum Power Supply

*Refer to the schematic in **Figure 2***. Transformer T1 supplies a nominal secondary voltage of 28 VAC RMS to bridge rectifier BR1 which charges capacitor bank (C6, C7, C8) through power resistors (R13, R14). Resistor R15 and shunt regulator VR1 provide a (+) five volt regulated rail for the digital electronics.

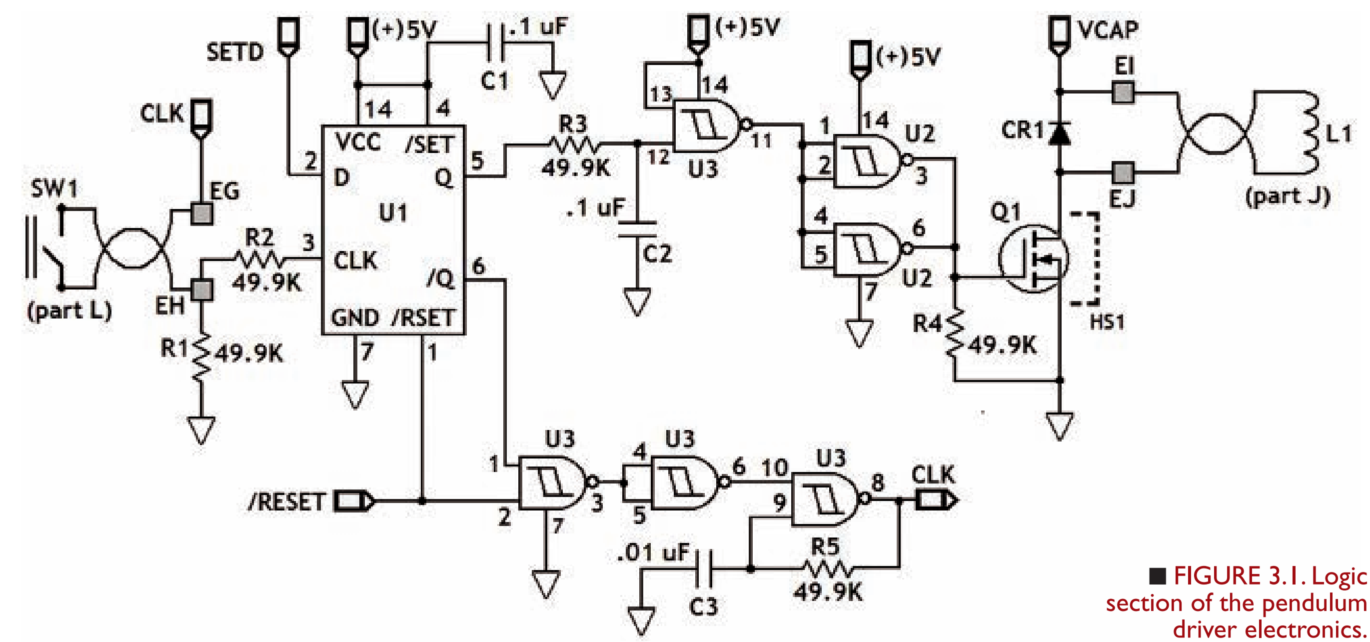
The Pendulum Driver Electronics.

*Refer to **Figures 3.1**, **3.2**, **4**, and **5***. Magnetic switch SW1 detects passage of the plumb bob magnet C over the center of coil L1. A 1 kHz clocking square wave, CLK, is applied to CLK input U1-3 only if the switch closes when capacitors (C6, C7, and C8) are fully charged. CLK is generated by the U3 relaxation oscillator comprised of U3 (8, 9, and 10), C3, and R5.

If /RESET is high at U1-1 when U1 is clocked at pin 3, then /Q goes low — this turns off the CLK and also charges C2 through R3. Together, C2 and R3 create a delay with a time constant of about 50 milliseconds, after which U2 (3,



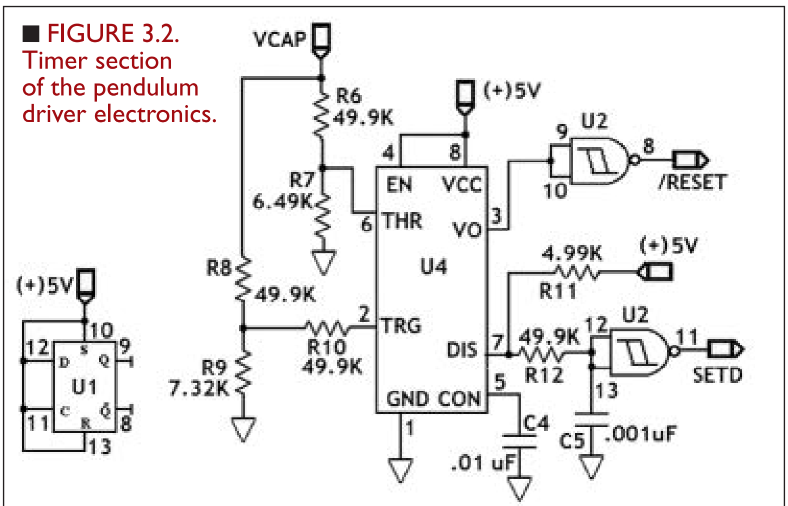
■ FIGURE 2. Schematic of the pendulum power supply.



■ FIGURE 3.1. Logic section of the pendulum driver electronics.

6) transitions high, turning on MOSFET Q1 and discharging VCAP through solenoid L1. This delay gives the plumb bob C time to travel off-center so that L1 can give it an optimal sideways magnetic "push."

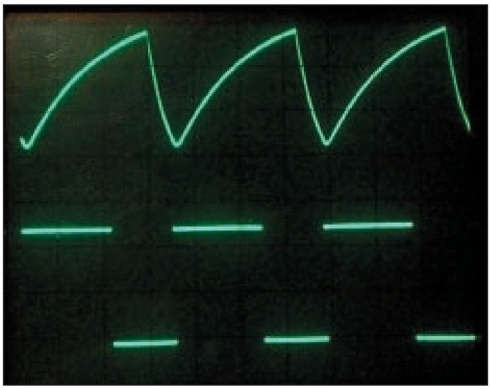
■ FIGURE 3.2. Timer section of the pendulum driver electronics.



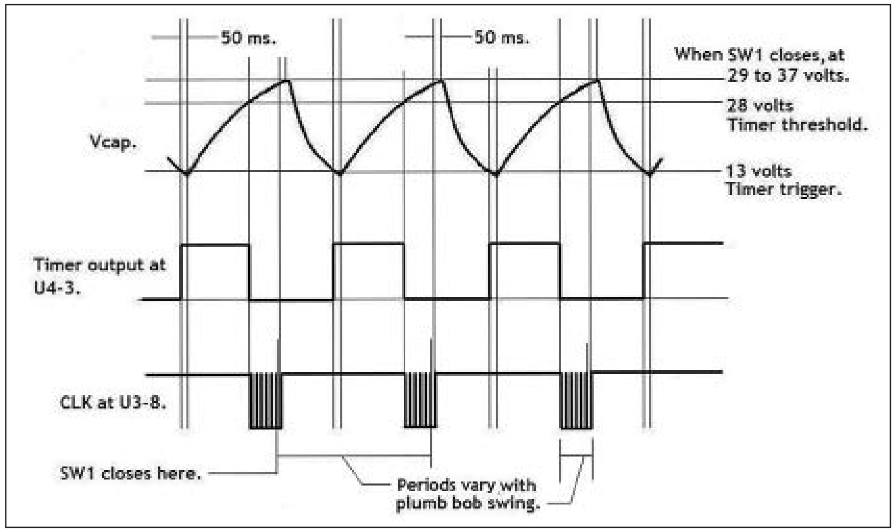
U4 (**Figure 3.2**) displays the versatility of the TLC555 CMOS timer when U3 is used in the astable mode — we use the timer to control the charge and discharge of voltages much greater than its own operating voltage of (+) five volts. Two voltage divider sets — (R6, R7) and (R8, R9) — attenuate VCAP down to the required trigger level (1.67 volts on U4-2) and threshold level (3.33 volts on U4-6) for astable operation. Note that output U4-3, acting through U2-8, controls the resetting of the flip-flop at U1-1; this prevents retriggering of the flip-flop from occurring until storage capacitors (C6, C7, C8) are fully charged.

As we see in **Figures 4** and **5**, the VCAP waveform lags the timer output, Vo, at U4-3 by the

50 millisecond delay introduced by R3 and C2. Note also that U2 (11, 12, 13) provides a short 50 microsecond "housekeeping" delay to prevent SETD from setting the flip-flop's D input (U1-2) high while /RESET at U1-1 is bringing the flip-flop out of reset.



■ FIGURE 5. Timing photograph of the pendulum driver electronics.



■ FIGURE 4. Timing diagram of the pendulum driver electronics.

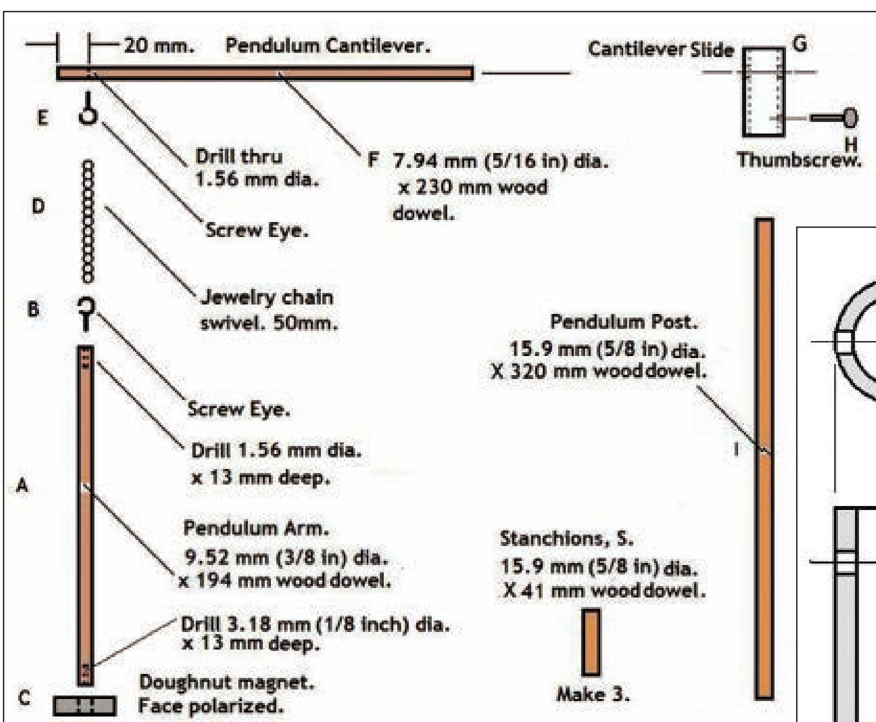
How To Make It:
Assemble The Pendulum Arm

See **Figures 6.1** and **6.2** to fabricate the relevant parts. These involve only simple cuts and a few drilled holes. A hand vice works well for the drill. Pendulum post I and the three stanchions, S, use the same dowel stock.

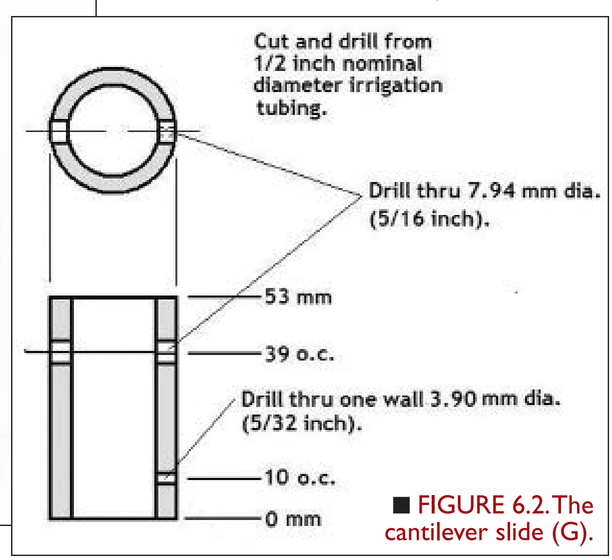
Lightly sand around the bottom circumference of A and then cement a doughnut magnet C with a 3/8" diameter hole snugly on to the bottom with general-purpose cement. Alternatively, a hole for a wood screw has been provided.

Note: The chain is necessary. *Do not use an "S" hook* to connect the pendulum arm to the pendulum cantileve, since this forces the pendulum into a largely fixed plane of oscillation.

Cantilever F will form a snug fit through the hole in slide G, but it will still be moveable as needed. The thumbscrew H will self-thread through the soft plastic of the slide.



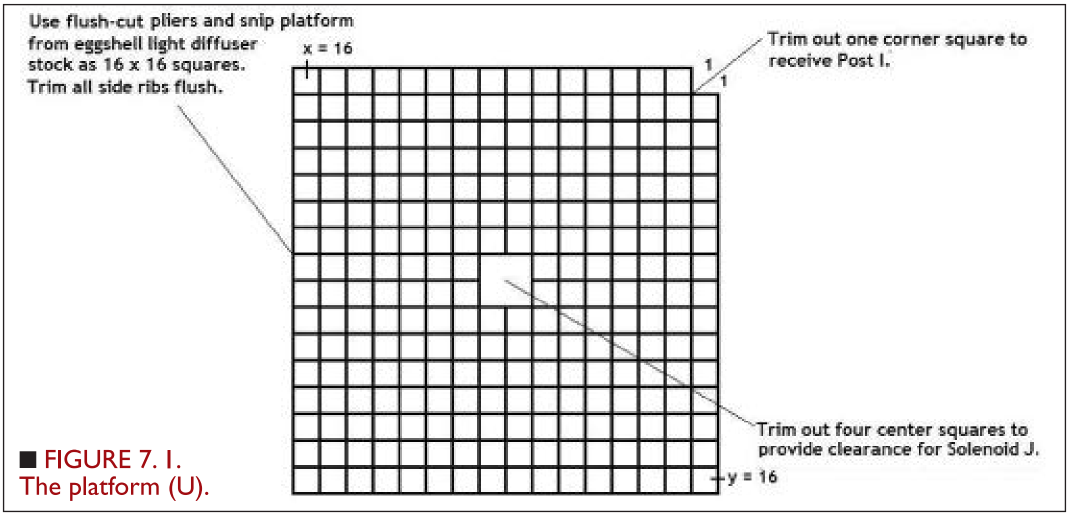
■ FIGURE 6.1. Pendulum arm parts.



■ FIGURE 6.2. The cantilever slide (G).

Assemble The Pendulum Platform And Base

The following order of assembly is critical to obtain a good fit of the parts because the "egg shell" plastic platform U is cut from a fluorescent light ceiling diffuser and is injection molded to exact dimensions. (See **Figure 7.1**.) Cut platform U from the diffuser stock as 16 x 16 complete squares using sharp flush-cut pliers.



■ FIGURE 7.1. The platform (U).

Fabricate the button magnets as shown in **Figure 7.2**. To orient the correct surface of the button magnets pointing upward, using the bottom of doughnut magnet C, make sure the button magnets are installed in the cap plugs so that the top side of each button REPELS the BOTTOM of magnet C in its mounted orientation.

As shown in **Figure 8**, drill the base T from pre-cut hardwood stock. (See the **Parts List**.)

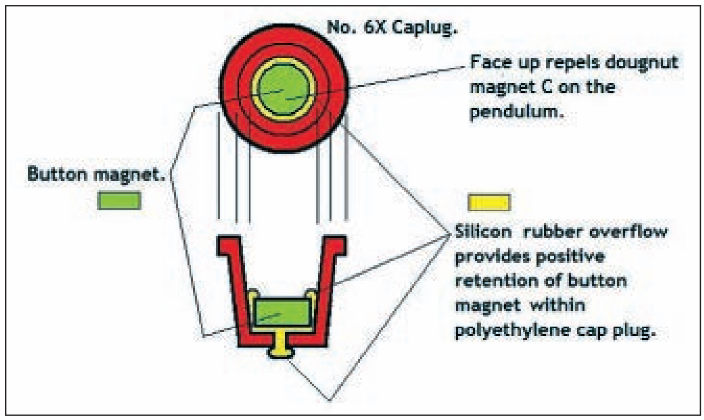
As shown in **Figure 9**, slide reducer R on to the bottom of post I, flange down. Glue post I into the drilled hole, flush with the bottom of base T. Then slide reducer R down snuggly on to base T and cement it to T with a small amount of cement under the flange of R.

Before the glue dries, use a vertical spirit level to make small adjustments to post I to insure that it is vertical in two directions. Set it aside to dry in a protected place.

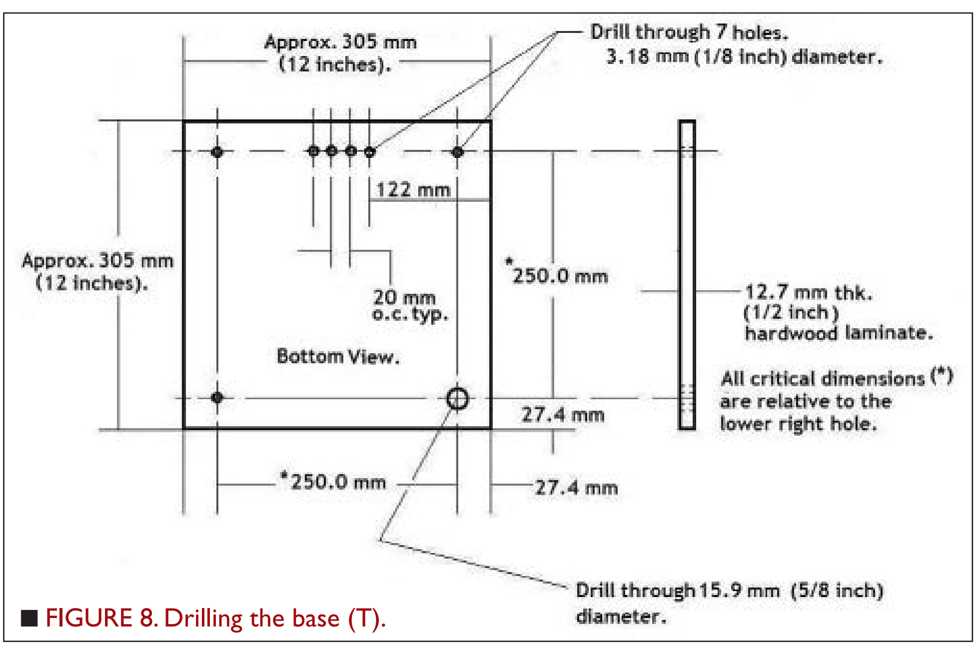
Continuing with **Figure 9**, insert three wood stanchions, S, into the corner closed cells of platform U. If necessary, lightly sand the stanchions around the top 1/2 inch of their circumferences to produce a tight but sliding fit. Bring the top of each stanchion flush with the top of U. Slide three reducers, R, on to the three stanchions.

Slide the entire assembly of S,U up against post I so that I is flush with the sides of the open corner square in platform U. Visually insure that the perimeter of platform U is parallel to the sides of base T. Keep the stanchions inserted in U, then carefully lift up each remaining corner of U and apply ample wood glue to the bottom of each stanchion S, reseating the stanchions firmly onto base T by pushing down on platform U. Set a few books on the platform to apply pressure, and allow the assembly to dry.

When dry, attach three feet, V1, to base T by drilling back through the three stanchion holes in the bottom of

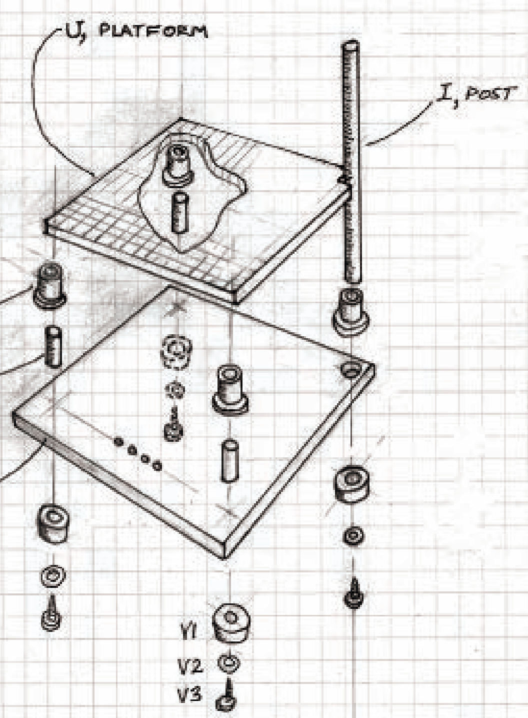


■ FIGURE 7.2. Button magnet fabrication using cap plugs.



■ FIGURE 8. Drilling the base (T).

platform T, to a total depth of 25 mm (one inch), and attaching each foot with hardware V2 and V3. Attach a foot V1 to the bottom of post I also. Apply a small amount of wood cement neatly to the bottom flanges of each reducer, R, and seat them firmly on to base T. Wipe away any excess wood cement immediately with a damp rag.



■ FIGURE 9. Assembly of the base and platform.

Wiring The Switch And Winding The Solenoid

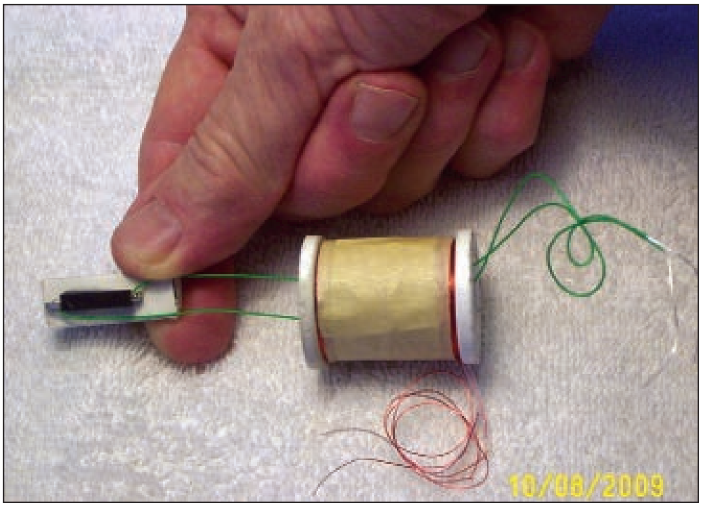
The coil form can be constructed from two PVC irrigation reducers back-to-back as shown in **Figure 10.1** and **10.2**. Alternate winding forms are possible, but you must achieve the specified turns to create an adequate magnetic field. With an emergent lead length of 250 mm (10 inches) shown, wrap 500 turns of 32 AWG (or 700 turns of 30 AWG) insulated magnet wire around J and secure the windings tightly with square-cut masking tape. Keep the windings approximately uniform. Dress the leads down and out to the left side of J and secure with PVC cement.

Cut wires M1 and M2 to 250 mm length using 30 AWG solid wire and strip/sand back the insulation from one end of each wire about 1/2 inch. Wrap and solder these ends to the flat ribbon leads of magnetic switch L (circuit designator SW1), bending the soldered ribbons as shown in **Figures 10.1** and **10.2**.

Attach an ohmmeter to the switch leads. Since switch L (SW1) will be mounted vertically, it is important to determine which end will activate the switch closure when

PARTS LIST

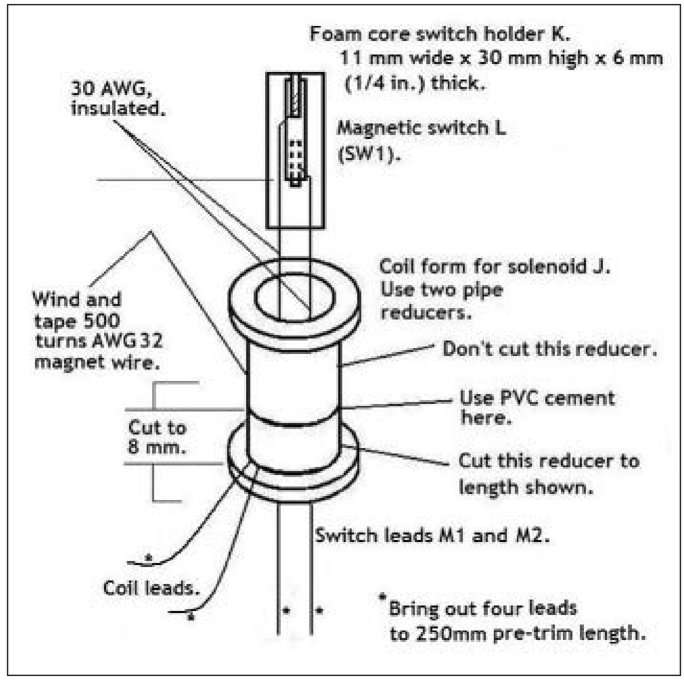
DESCRIPTION	DESIGNATOR	QTY	MFG/PART #	SOURCE
Mechanical				
Plywood Base T, birch, 12 mm x 12" x 12".	T	1	Revell SKU 307232	
			Often stocked,	
			but can be ordered	MI or phone
Platform U, white eggcrate louver	U	1	Lithonia Lighting L2GTPLTS	1-800-MICHAELS
			643335. H/D: U546021	HD
Post I, 5/8 inch diameter wood dowel	I	1		HD; LO; AH
Stanchion S, 5/8 inch diameter wood dowel	S	3		Post I mat'l.
Pendulum arm A, 3/8 inch diameter wood dowel	A	1		HD; LO; AH
Pendulum cantilever F, 5/16 inch wood dowel	F	1		HD; LO; AH
Reducer bushings, irrigation, PVC, Sched. 40, 3/4"x 1/2"	R	4	Dura USA D2466	HD; AH; LO
Reducer bushings, irrigation, PVC, Sched. 40, 1/2" x 1/4"	J	2	Dura USA D2466	HD; AH; LO
Washer, flat, metal, 8 mm (5/16 inch) diameter	V2	4	(any)	HD; AH; LO
Wood screw, pan head Phillips, #8 x 1-1/4 inches long	V3	4	Crown Bolt 24961 or equiv.	HD; AH; LO
Enclosure, aluminum, two pieces, 8 " x 6 " x 3.5"	(None)	1	LMB-HEEGER LMB #TF-783	FY
Screw eyes, 1" long x approx. 3/8 " I.D.	B, E	2	Crown Bolt #214, or equiv.	HD; AH; LO
Cap plugs, Type T, polyethelene. Ask for 10 pcs	(None)	8	Size 6-X cap plug	
Magnets, round, ceramic, 1/2 inch O.D.	(None)	6	RS: Catalog No. 64-1883	RS
Chain, jewelry, fine scale, 244 cm (96 inches)	D	1	Hirschberg & Schutz	MI or phone
			Item No. MM32329-01	908-810-1111
Magnet, ceramic, "doughnut," 3/8 inch I.D., five pack	C	1	RS: Catalog No. 64-1888	RS
Magnet, ceramic, round, 1/2 inch O.D., five pack	(None)		RS: Calalog No. 64-1883	RS
Pipe, PVC, irrigation, x inch O.D. (scrap piece)	G			
Fuse holder, cartridge, panel mt., #3AG, 1/2 inch dia., 10A/250V	FS1	1	DK: F1484-ND; RS: 270-364 or	
			FY: NTE 74-FH6-8	DK; RS; FY
Fuse, 1/8 A, bayonet (size)	F1	1	Various	DK; RS
Grommet, black rubber, 3/8" dia. For line and signal wiring	(None)	2	Various	HD; LO; RS
Line cord, 18 AWG x 3, gray rubber insulation, six feet	(None)	1	JA: 38009	JA
Closed end spade lug for safety (green) wire to enclosure	SW1	1	RS: 64-043 (10 pieces)	RS
Standoffs, hex body, 11/16 long each, with two 4/40 screws				
each, four pack	T1	4	RS: 176-195	RS
Switch, magnetic, plastic molded (only)	SW1 (or L1)	1	SRC Devices Dyad®	
			DK: 420-1047-ND	DK
Fahnestock clips for EG, EH, EI, and EJ connections on Base T		4	EL175Pk/10 (10 pieces)	ON
Wire, magnet, 30 AWG. Note 32 AWG is preferred			RS: 28-1345 (3 gauges, inc. 30)	RS
Transformer, 120 VAC to 24 VAC, with PCB pins	T1	1	Tamura 3FS-524 or Microtran	
Bumpers, screw, white 22 mm (7/8" diameter), four pack	V1	4	Shepherd Hdwr. Products,	



■ FIGURE 10.2. Switch and coil fabrication.

in close proximity to magnet C. Slowly pass the bottom face of C over each end of L while watching the ohmmeter for contact closure. Once established, maintain this up/down orientation of L while threading leads through the hole in coil form J. Apply a small amount of wood cement to the sides of switch mount K and position the switch in the coil form. Dress the leads down and out to the bottom left. Secure the leads neatly with PVC cement.

***"Things fall apart, the center cannot hold,
Mere anarchy is loosed upon the world."***
— Yeats



■ FIGURE 10.1. Switch and coil fabrication diagram.

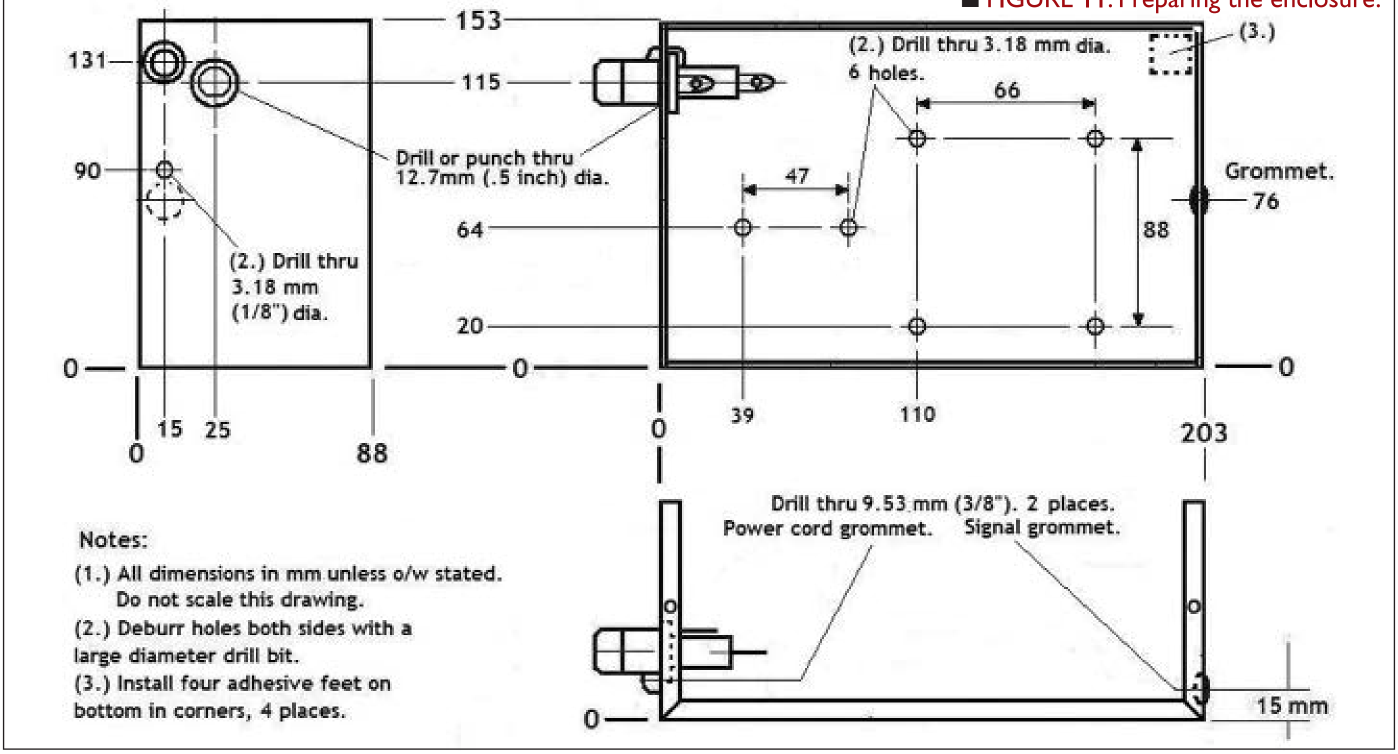
			No. 9131, or equiv.	HD
Bumpers, vinyl, clear, 19 mm (3/4 diameter), 12 pack		4	Shepherd Hdwr. Products, No.9565, or equiv.	HD
Heatsink for TO-220 pkg. Mount w/ silicone grease	HS1	1	Jameco Valuepro No. 326596	JA
Flat tie holder, Nylon. Use with #6 mtg. hardware and 4 1/2" cable ties	(None)	2	Richco FTH-13 Series Ask for samples	RI
Thumb screw, #10-32 thread x 3/4" long	H	1	(various)	HD; AH; LO
Semiconductors, leaded only				
CMOS dual type D flip-flop, 14 DIP	U1	1	74HC74N; DK: 568-1491-5-ND	DK
CMOS quad Schmitt nand, 14 DIP	U2, U3	2	74HC132N; DK: 568-1395-5-ND	DK
CMOS timer 8 DIP	U4	1	LM555; DK: LM555CNNS-ND	DK
Transistor, Power MOSFET, E-mode, TO-220 pkg	Q1	1	Int'l Rec. IRF 510; JA: 209234	JA
Diode, rectifying, 800 volts PRV	CR1	1	General Semi. 1N4006; DK: 54GICT-ND	DK
Voltage reference, five volts, TO-92	VR1	1	LM385Z-ND	DK
Rectifier, bridge, 100 PRV, one amp	BR1	1	Diodes Inc. DF-M Series; DK: DF01MDI-ND	DK
Passive Components, leaded only				
Resistor, carbon film, 49.9K, 1%, 1/4 watt	R1, R2, R3, R4, R5, R6, R8, R10, R11, R12	10	Yageo; DK: 49.9KXBK-ND	DK
Resistor, carbon film, 6.49K, 1%, 1/4 watt	R7	1	Yageo; DK: 6.49KXBK-ND	DK
Resistor, carbon film, 7.32K, 1%, 1/4 watt	R9	1	Yageo; DK: 7.32KXBK-ND	DK
Resistor, 100 ohms, five watts	R13, R14	2	Digi-Key; DK: TWM5K100E-ND	DK
Resistor, 1.3K ohms, two watts	R15	1	Phoenix; DK: PPC1.3K-2CT-ND	DK
Capacitors, leaded only				
Capacitor, .1 µF	C1	1	EPCOS; DK P4910-ND	DK
Capacitor, 1 µF	C2	1	BC Mono-Kap™; DK BC1151CT-ND	DK
Capacitor, .01 µF	C3, C4	2	EPCOS; DK: P4904-ND	
Capacitor, .001 µF	C5	1	EPCOS; DK P4898-ND	
Capacitor, 3300 microF, 50 WVDC, x %, alum. electrolytic	C6, C7, C8	3	United Chemi-con; DK: 565-1118-ND or Nichicon; DK: 493-1347-ND	DK

Source abbreviations:
AH: Ace Hardware stores; DK: Digi-Key at **digikey.com**; FY: Frye's Electronics; HD: Home Depot; JA: Jameco at **jameco.com**; LO: Lowes Hardware; MI: Michaels craft stores at **michaels.com**; ON: **Onlinesciencemall.com**; RI: **richco-inc.com**.

Preparing The Enclosure

Drill and prepare the enclosure as shown in **Figure 11**. If you drill through from the bottom, remember that the hole locations shown are now reversed. Mount four stand-offs as shown using No. 4-40 screws with star washers under the heads. Tighten them hard.

■ FIGURE 11. Preparing the enclosure.

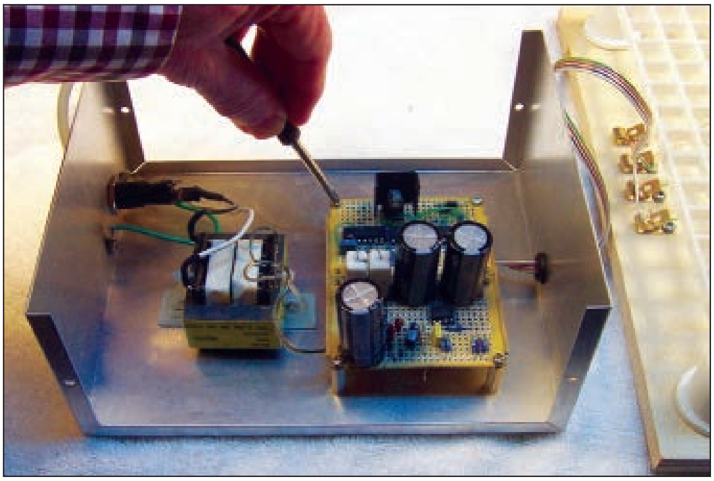


Wiring And Installing The Transformer

WARNING: 120 VAC is easily handled safely, but it can penetrate human flesh and can even be lethal if you are superbly careless. **Never** modify wiring or insulation with power applied. *Failure to follow these wiring instructions constitutes an improper usage of this project and equipment.*

Mount T1 tightly upside-down — with the bobbin seated on electrical tape — with nylon cable ties and cable feet (**Figure 12**). Use #6-32 hardware to secure the feet — adhesive feet will break loose! Alternatively, bolted cable clamps can be used. Thread the power cord through the power grommet. Solder the black wire to the fuse holder FS1, making sure that FS-1 is placed only in the HOT (black) line. Continue the black wire from the opposite end of FS1 to T1-1. The NEUTRAL (white) line solders directly to T1-2. Connect the green safety wire of the line cord to the chassis using a closed-end spade lug that has internal star burrs.

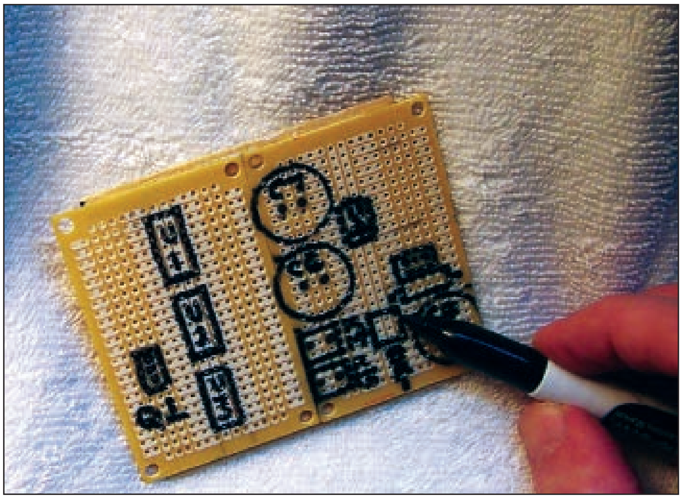
■ FIGURE 12. Wiring and mounting the circuit board.



Proceeding, install fuse F1 and *without plugging in the power,* run a continuity check of the primary with an ohmmeter. The black HOT wiring to EA should connect to the narrow blade of the wall plug and the white NEUTRAL wire to EB should connect to the wide blade. Also check continuity between the wide and narrow blades. You should see the transformer's primary winding resistance of about 75 ohms. Then, remove the fuse while doing this and observe the primary circuit come open. Replace the fuse and see the primary resistance return.

Now, cover T1 pins 1 and 2, and any other exposed wiring with heat-shrink tubing and/or electrical tape. Solder T1 secondary pins 6 and 7 together with bare wire.

Wiring The Circuit Board



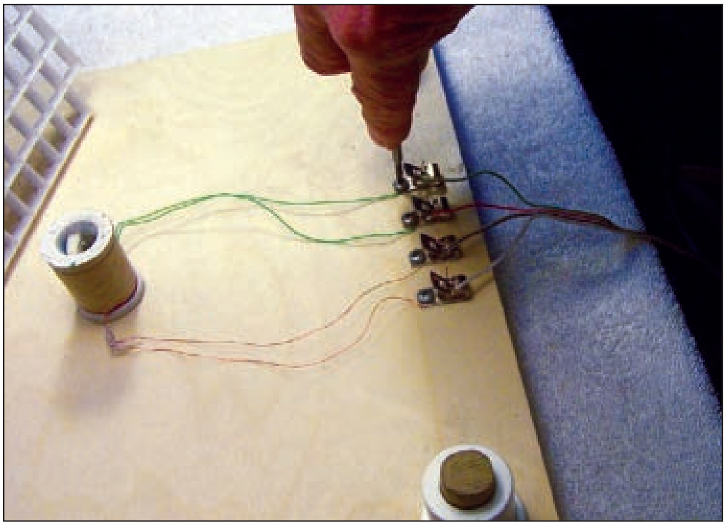
■ FIGURE 13. Component layout on printed circuit boards.

A printed circuit board for the pendulum drive circuit is offered by the author. One simple alternative is to wire the circuitry on two small prefabricated boards — such as RadioShack part number 276-150 — joining them together using Gorilla® glue, working over wax paper. (See **Figure 13**.) I prefer to solder up this kind of board by soldering with 30 AWG Kynar™ solid wire wrap wire. Use tweezers.

First, wire only the power supply from BR1 through VR1, omitting U1, U2, U3, and U4. Temporarily connect the T1 secondary (pins 5 and 8) to the circuit board at points C and F, and use a voltmeter to check for (+) 4.8 volts to (+) 5.2 volts between the IC power and ground pins. Then, turn off the power, and observing electrostatic handling precautions, install the remaining CMOS components.

Bring out circuit points EG, EH and EI, EJ as two twisted wire pairs. Use stranded hook-up wire, cut to about a one meter (approx. three feet) length. Alternatively, ribbon cable can be used. (See **Figure 12**.)

Final Assembly



■ FIGURE 14. Wiring the base (EG, EH, EI, EJ, upper to lower). The screwdriver is on clip EG.

Mount the circuit board on the remaining four standoffs (**Figure 12**) and route the wire pairs EG, EH and EI, EJ out of the front grommeted hole in the enclosure.

Snap the mounting platform U down on to the stanchions, S, and locate and closely mark the position in U for the coil assembly (J, K, L). Remove U and cement the coil assembly (J, K, L) to the marked center of the grid with silicone rubber. When dry, place four wood screws through four Fahnestock clips and mount them loosely in the four holes EG through EJ (**Figure 14**).

Cut and sand the insulation off of each lead coming from the coil and switch for about 1/2 inch, such that a 90-degree bend of bare wire will fit flat under its respective Fahnestock clip — about 1/4 inch below the mounting screw. Do not wrap the wires around the screws, since they will "scroll" and break when the screws are tightened. As shown in **Figure 14**, mount the switch leads M1 and M2 flat under clips EG and EH, and mount the coil leads under clips EI and EJ. Polarity is not yet important.

Self-thread thumb screw H in the bottom hole of the cantilever slide G and insert pendulum cantilever F through the hole in G. Place this assembly on top of post I. Hook the pendulum arm A with chain D on to hook E on the cantilever. The cantilever may now be adjusted in three dimensions by sliding through G, and with the thumb screw H. Adjust it so that magnet C rests centered on coil J below, and about 1/4" to 1/2" above it. When on target, tighten H.

Testing

Strip and connect the two wire pairs EG, EH and EI, EJ from the enclosure into the eyes of their respective Fahnestock clips. Select a length for this wiring which will facilitate placement of the enclosure (a) under base T; or (b) beside base T; or (c) removed from the base and otherwise out of sight.

Refer to the circuit waveforms in **Figures 4** and **5**. Apply power and check the power rail for stable, quiet (+) five volt operation. Using your oscilloscope, hold pendulum magnet C over switch SW1 and observe the ramp waveform at trigger U4-2 run freely up and down. Monitor the gate of Q1 for oscillation. Hold magnet C well away from SW1 and observe U4-2 become static at about (+) 5.1 volts.

IMPORTANT! Solenoid J should push away (i.e., repel) magnet C when it is pulsed. If not, reverse the wires at clips EI and EJ.

For further information, contact nglooper@gmail.com.

Experimental Chaotic Brain Teasers

The assembled button magnets can now be placed experimentally in the matrix of platform U to produce chaotic operation. Note that even symmetrical placements of the button magnets still produces chaotic behavior due to the inherent nonlinearities of the magnetic fields involved. Also, you don't need many magnets to produce complex results. To start, try the following placement of five magnets using the x, y locations as shown in **Figure 7**, relative to post I: (5,7), (5,10), (9,5), (9,11), and (12,6).

Research Problem 1. Planetary Orbit Stability In A Binary Star System. Consider pendulum magnet C as representing a planet in a binary star system and two button magnets inserted upside down into the bottom of platform U as representing two parent stars in slow orbital motion around each other, and therefore attracting the planet. Can you nudge the planet into an elliptical or circular orbit that is stable over several minutes? Question: Do you think that the orbits of the planets in a binary star system over very long times are guaranteed to be stable?

Research Problem 2. Static Equilibrium. Using any number of repelling magnets and with power applied to the electronics, can you find a button magnet configuration which will result in the pendulum eventually becoming trapped and permanently at rest outside of the center of the platform?

Research Problem 3. Periodic Behavior. Using at least one button magnet, can you find a button configuration that will result in the pendulum adopting a constant period of oscillation?

After you try these research problems, come up with some of your own to test out the theories. It's a good thing to bring a little chaos to your life. **NV**

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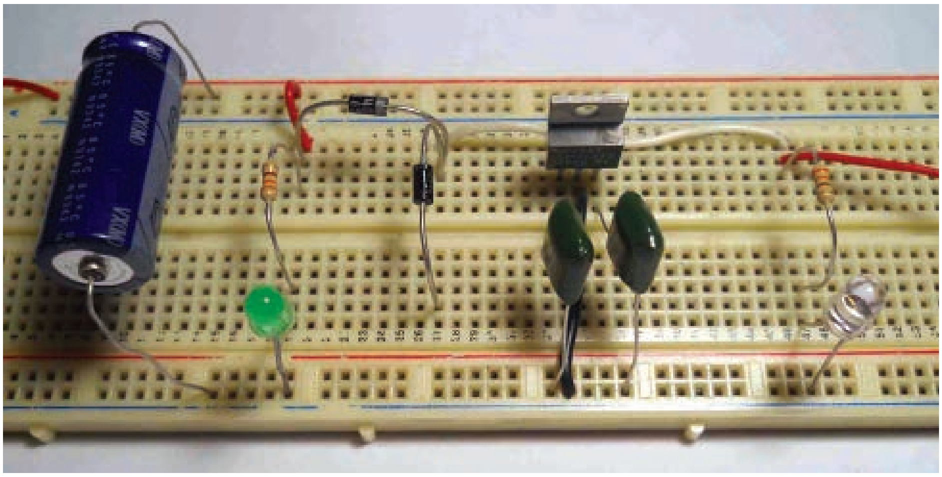
A SIMPLE DC UPS

By Philip Kane
Photos by Sarah Kane

An uninterruptible power supply (UPS) ensures the continuous operation of critical electronic equipment. They are especially necessary if you live in an area where there are frequent power failures. They are manufactured to meet a wide range of power requirements, from backing up your personal computer to keeping your entire home office (or workshop) going during a power failure. Most UPS systems are designed to transparently maintain AC power to your equipment. They provide for a smooth transition from main power to backup power and back again.

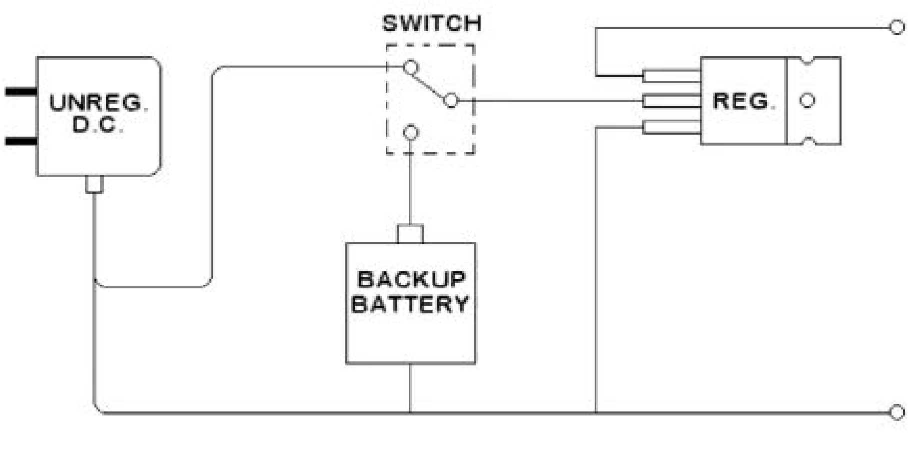
There are a number of applications that have relatively low power requirements and run on DC rather than AC voltage but must also remain operational in the event of a main power failure. These include small security sensor modules, data acquisition, and status monitoring devices among others.



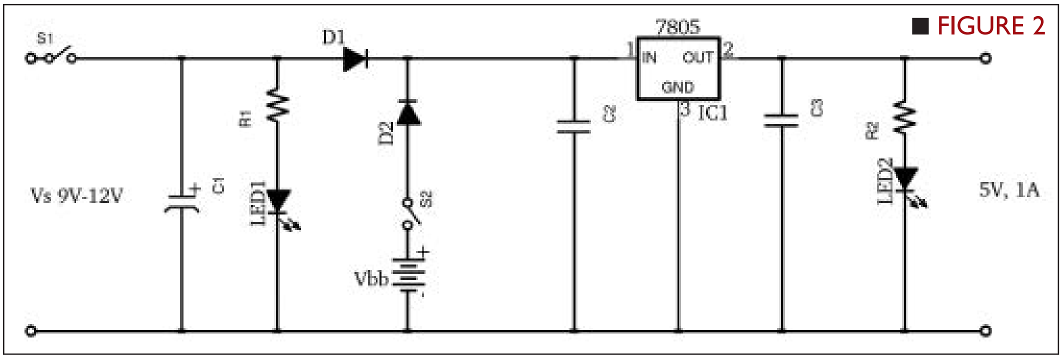
This article describes a simple UPS circuit that you can incorporate into the design of your own low power DC project to ensure continued operation during short term power failures.

The block diagram in **Figure 1** shows the organization of a simple DC UPS. It consists of an unregulated DC source, a backup power source, switching logic, and a voltage regulator. The voltage regulator supplies the application with regulated DC power. The input to the voltage regulator normally comes from the unregulated DC source. If the main power is interrupted, then the switching logic switches the backup power source to the input of the regulator. When main power is restored, the unregulated DC source is switched back into the circuit.

■ FIGURE 1



About the Circuit



■ FIGURE 2

The circuit shown in **Figure 2** is a UPS intended for low power applications. It is essentially a linear regulator with battery backup. It provides a regulated 5V DC from an unregulated DC input of at least 9V.

LED1 is the main power indicator. It remains on as long as the regulator is being supplied by the main power source. LED2 is the output power indicator. Taken together, LED1 and LED2 are used to determine the status of the UPS.

Diode D1 isolates the main power source from the backup circuit, while diode D2 comprises the switching logic that will be described later. Capacitors C1, C2, C3, and IC1 form the linear regulator section of the circuit. The battery backup feature can be eliminated from the circuit via switch S1. Note that S1 and S2, as well as LED1 and LED2 — while useful for testing the UPS prototype — are optional and need not be included in your application.

Circuit Operation

The 7805 is a standard linear 5V regulator. It receives input from either the main power source Vs or the backup source Vbb.

Vbb is provided by either alkaline or non-rechargeable lithium batteries. To determine the maximum and minimum values for Vbb, you must consider the forward voltage drop across D1 and D2, as well as the specified minimum input voltage for the 7805, which is 7V.

Let's assume that the forward voltage drop for D1 and D2 is 1V. If Vs is 9V, then the voltage at the cathode of D2 (and also the input to the regulator) is 8V. Therefore, Vbb can't be greater than 9V if D2 is to remain reverse-biased. In order to ensure that if Vs fails, the input to the 7805 will be at least equal to the specified minimum, Vbb can't be less than 8V. If Vs were higher — say 12V — then there would be a wider range for Vbb (8V to 12V).

The 7805 will provide a regulated 5V output for any input voltage from its specified maximum and minimum input voltages. Choosing a value for Vbb that is close to the minimum input voltage can help to extend battery life in situations where Vs may frequently fall between its normal level and the 7805's minimum input voltage. However, over time, Vbb will fall below its nominal value. If you choose Vbb at or close to its minimum possible value, then this will shorten its usable life. A good choice for Vbb will be a compromise between the specified maximum and minimum values.

Two factors to consider when choosing D1 and D2 are the required load current and the leakage current. If — as in this case — you're using non-rechargeable lithium or alkaline batteries, you should choose a diode with low leakage current.

We used a 1N5400 diode in our prototype. This diode has a specified maximum reverse (leakage) current of 5 µA at 50V DC (reverse voltage). Its forward current rating is 3A which is more than adequate to deal with the 1.5A maximum output current of the 7805.

PARTS LIST

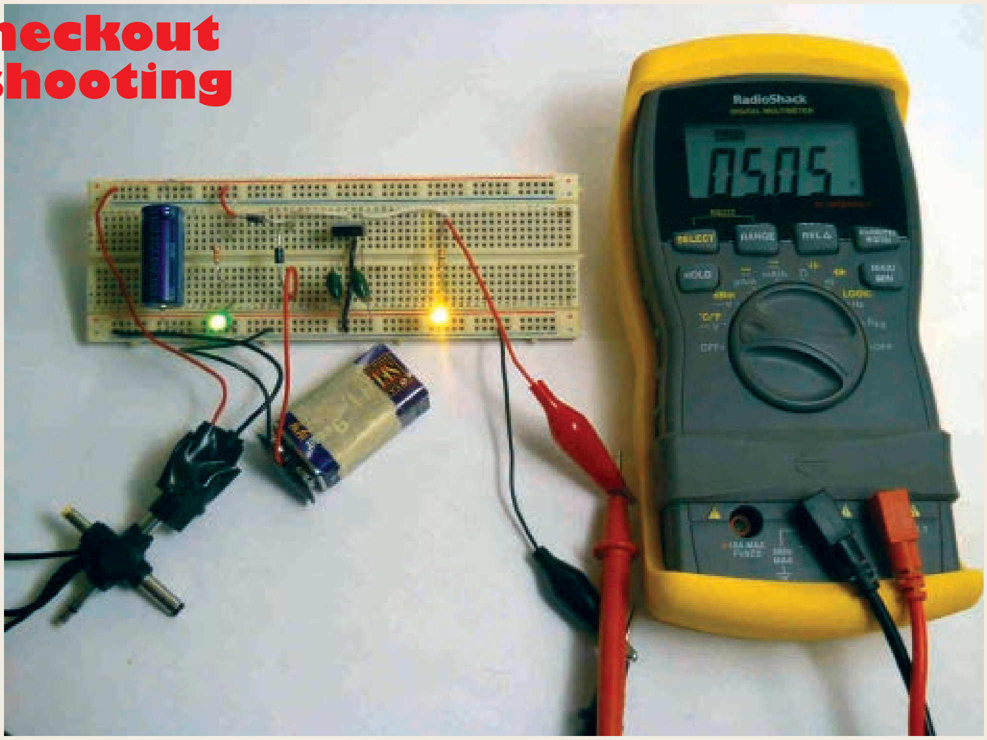
ITEM	DESCRIPTION
C1	1,000 µF electrolytic capacitor
C2, C3	0.1 µF capacitor (polyester or mylar)
D1, D2	1N5400 diode or any diode with a maximum forward current rating of at least 1.5A and low reverse leakage current
IC1	LM7805 (or equivalent) 5V regulator
LED1, LED2	Light emitting diode (2 mA)
R1, R2	330 ohm resistor
S1, S2	SPST switch (optional)

Construction

If you intend to use this as a stand-alone power supply, the entire prototype circuit can be assembled on a piece of perf board using point-to-point wiring. Mount the 7805 on a heatsink.

If you intend to incorporate the UPS circuit into your own application, then the backup battery configuration will be a significant factor in your choice of an enclosure.

Prototype Checkout and Troubleshooting



Before powering up the circuit, check all connections. Make sure that you have a DC adapter that can deliver the required maximum current at the required input voltage. Use a fresh battery. With the backup battery out of the circuit, check out the circuit as follows:

- Set S1 and S2 to their open (off) positions.
- Connect the DC adapter to the UPS and plug it into the wall outlet.
  - Close S1. Both LED indicators should be on. If neither LED is on, then suspect the adapter and check the voltage across the input to the UPS. Note: The voltage measured at the adapter output when it is not under load will most likely be higher than the rated voltage at the specified load current. For example, the output of the nine volt adapter that I used was 11.2 volts.
  - If LED1 is on and LED2 is off, first check the UPS output voltage. If the UPS output voltage is okay, then check LED2 and its limiting resistor. If there is no UPS output voltage, then measure the voltage on the input side of the 7805 regulator. If there is no regulator input voltage, then suspect D1. Otherwise, suspect the 7805.
  - If LED1 is off and LED2 is on, then check the wiring for LED1 and its limiting resistor.
- Measure the current between the anode of D2 and ground. It should not exceed the specified leakage current for the diode you have chosen.
- Verify that the regulator portion of your circuit is operating correctly by varying the UPS output load and measure the output voltage. The output voltage should remain relatively constant. Be careful not to exceed the 7805 maximum current limit.
- With S1 still closed, place the backup battery in the circuit.
- Close switch S2 and place S1 in the open (off) position (or remove the adapter from the wall) to simulate a power failure. LED1 should go off. LED2 should remain on.
  - Measure the output voltage. It should still be at the regulated level.

The configuration of LED1 and LED2 indicates the status of the UPS and the condition of the main power line. Assuming both S1 and S2 are closed, the status of the UPS is shown in **Table 1**.

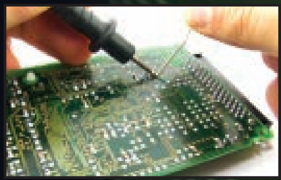
LED1	LED2	Condition
Off	Off	Main power off. No backup battery or low backup battery.
Off	On	Main power failure. UPS in backup mode.
On	Off	Main power on. However, UPS has apparently failed. Possible causes include bad battery, open diode, bad regulator, or bad indicator LED2.
On	On	Main power on. UPS operating properly.

Table 1: UPS status conditions assuming switches S1 and S2 are closed.

Conclusion

There are obviously a number of improvements that you can make to the basic circuit presented here. You can replace the standard 7805 with a variable voltage, low dropout (LDO) regulator. The lower minimum input voltage of the LDO would extend the range of Vbb. Additionally, it can be configured for a range of output voltages. For example, you could use the same part to build a nine volt UPS to power a DC appliance or to design a five volt UPS into your next project.

Another possible improvement would be to replace the linear regulator with the more efficient switching regulator. **NV**



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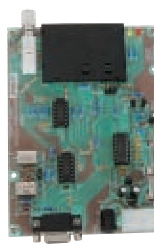

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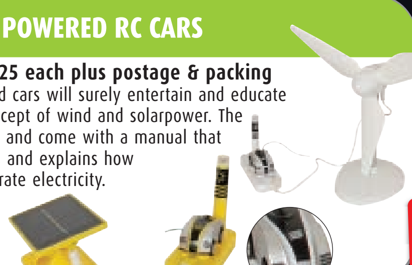

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- 9-12VDC @300mA
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new

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Power requirements:12V, 2.5A
Transducer voltage: 250VAC square wave
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Includes:
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BUILD A WI-FI SPRINKLER SYSTEM Part 1

By Bob Colwell

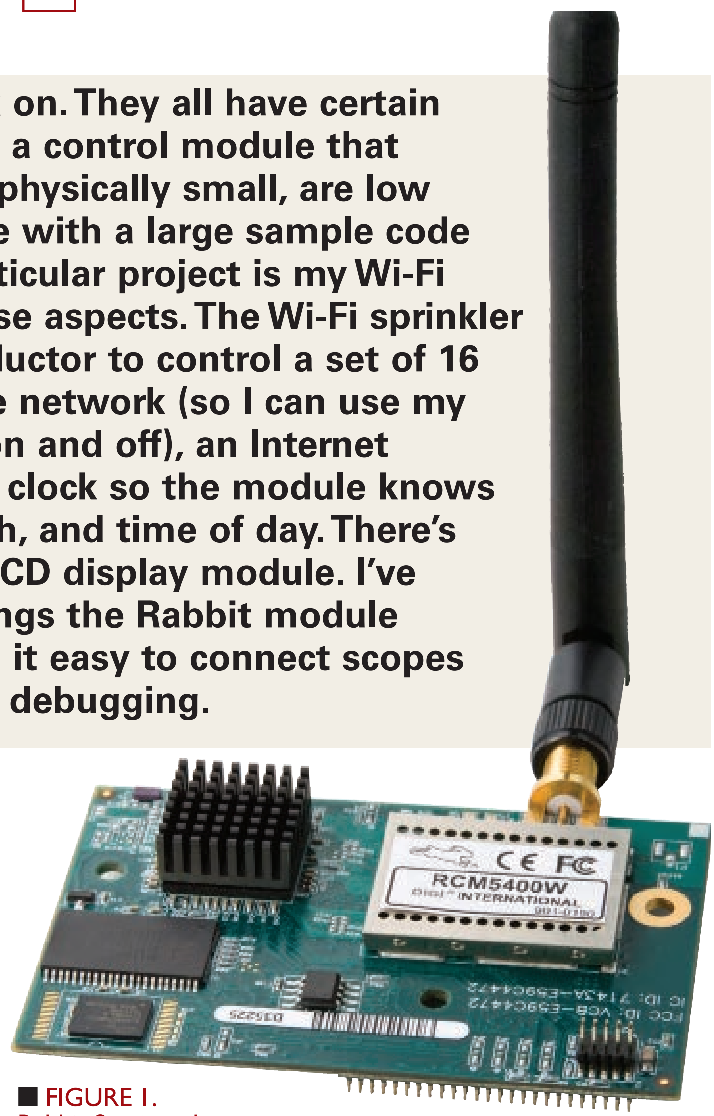
I have a lot of projects I want to work on. They all have certain things in common, such as they need a control module that speaks 802.11a/b/g fluently, they are physically small, are low power with lots of I/O port bits, come with a large sample code library, and don't cost much. One particular project is my Wi-Fi sprinkler system that exemplifies these aspects. The Wi-Fi sprinkler uses a module from Rabbit Semiconductor to control a set of 16 relays, Wi-Fi to connect it to my home network (so I can use my iPod in my yard to turn water zones on and off), an Internet connection, plus an internal real-time clock so the module knows the day of the week, day of the month, and time of day. There's also an interface to a standard 2x16 LCD display module. I've included a labeled "pin field" that brings the Rabbit module pinouts to a set of 50 stakes, to make it easy to connect scopes and logic analyzers to aid in software debugging.

We have a lot to cover, so this first article will show how to use the Rabbit module to do the basic functions for this project (or others). Next month, we'll talk more about the sprinkler-specific aspects of the design. Software is covered in a comprehensive file included in the downloads.

The Wi-Fi Module

Rabbit's Wi-Fi module has five general-purpose eight-bit I/O ports. The module uses some of the bits of some of the ports for Wi-Fi and other functions. If you read the documentation very carefully, you will find that all bits of Port A are available for your use. The same is true of Port D. Certain bits of Ports B and C have other duties that you can work around if necessary.

Rabbit's documentation states that RCM5450W ports can source or sink 24 mA and are guaranteed to swing an output voltage of 2.0V (0.4V low, 2.4V high). We will use these specifications in designing an appropriate relay driver circuit.



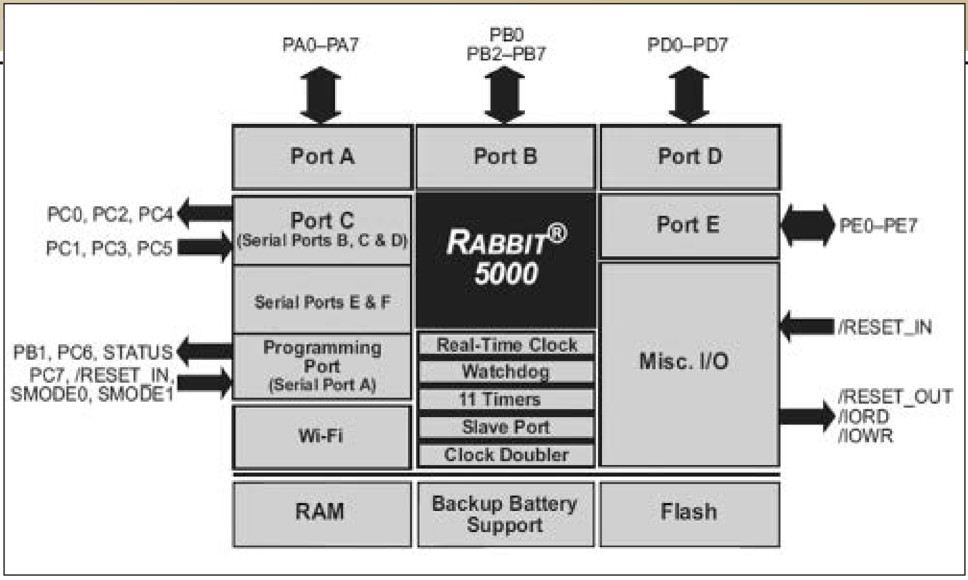
■ FIGURE 1. Rabbit Semiconductor RCM5450W Wi-Fi module.

Control by Relay

Almost every project needs to control something. The module needs to be able to turn on motors, energize circuits, or actuate solenoids like the ones inside the 24

VAC water valves used in yard sprinkling systems. We can get 24 VAC from a transformer, and because we won't turn on multiple zones at once, the current requirements are a trivial 75 mA. Now, we just need a way to control this electrical current to each zone's sprinkler valve. Triacs would work, but relays are cheap and easy to understand.

A relay is a magnetically controlled switch. Relay coil current causes a magnetic field that pulls on the switch and closes it. If you turn off the coil current, the magnetic field collapses and a spring pulls the relay switch open again. Coil actuation current is controlled by a simple transistor driver circuit, and the transistor is driven directly by the Wi-Fi module's processor.



■ FIGURE 2. Block diagram of the Rabbit RCM5450W module.

Relays and Their Drivers

With enough Rabbit port bits, we could just assign one bit to each relay (16 in all) and then ensure that the C code never drives more than one bit low at any given time. I tried that first, but after some misadventures using port bits that were already allocated to the Wi-Fi functions, I simplified the code by taking advantage of the one-zone-at-a-time rule. I put a latched 4:16 CD4515 decoder chip in the circuit, whose inhibit bit was controlled by another port output bit. I now had the flexibility to also handle the LCD interface. When the chip is first powered up, the CD4515's internal four-bit latch holds a random number, and the corresponding Y output will want to go active. For our Wi-Fi Sprinkler system, uncontrolled water would briefly flow. This prospect of wet mayhem is averted by the active-high 4515 Inhibit input. Until a Rabbit bit is set as an output, an internal pullup resistor holds the wire at logic-high. This makes PD 7 (see **Figure 3**) appear to be high, inhibiting the 4515 from selecting any of its 16 outputs during initialization.

Figure 3 shows the basic transistor relay driver circuit. When transistor Q1 is on, current is permitted to pass from Q1's emitter through the transistor to its collector and then down through the coil, energizing it so that a magnetic field is formed around the coil. This magnetic field pulls on the switches shown as Relay 1.2 and Relay 1.3, flipping those switches from their normally open state to a closed state, thus connecting pin 3 to pin 4, and pin 8 to pin 7. When Q1 is off, no coil current flows, and the relay's switch defaults to the upper connections (3 to 2, and 8 to 9). This project would work fine with only a single-throw single-pole relay, but these DPDT subminiature relays were cheap and small, and I figured as long as there were two contacts, why not gang them and cut the load current through each by half? That's why they're paralleled in this design.

The value of R1 must satisfy two constraints: keep the transistor off if the port output is high or not yet configured, and fully saturate the transistor otherwise. The manufacturer says their 5V relay coils are 178 ohms. A fully-on transistor exhibits an emitter-to-collector drop of approximately 0.1V. The coil current will be (5 – 0.1)V / 178 ohms, or approximately 28 mA. Typical transistor beta, or gain, would be around 100, so we need at least 1/100th of 28 mA in the transistor's base to get that collector current, or 0.28 mA. Let's round up to 0.5 mA of base current.

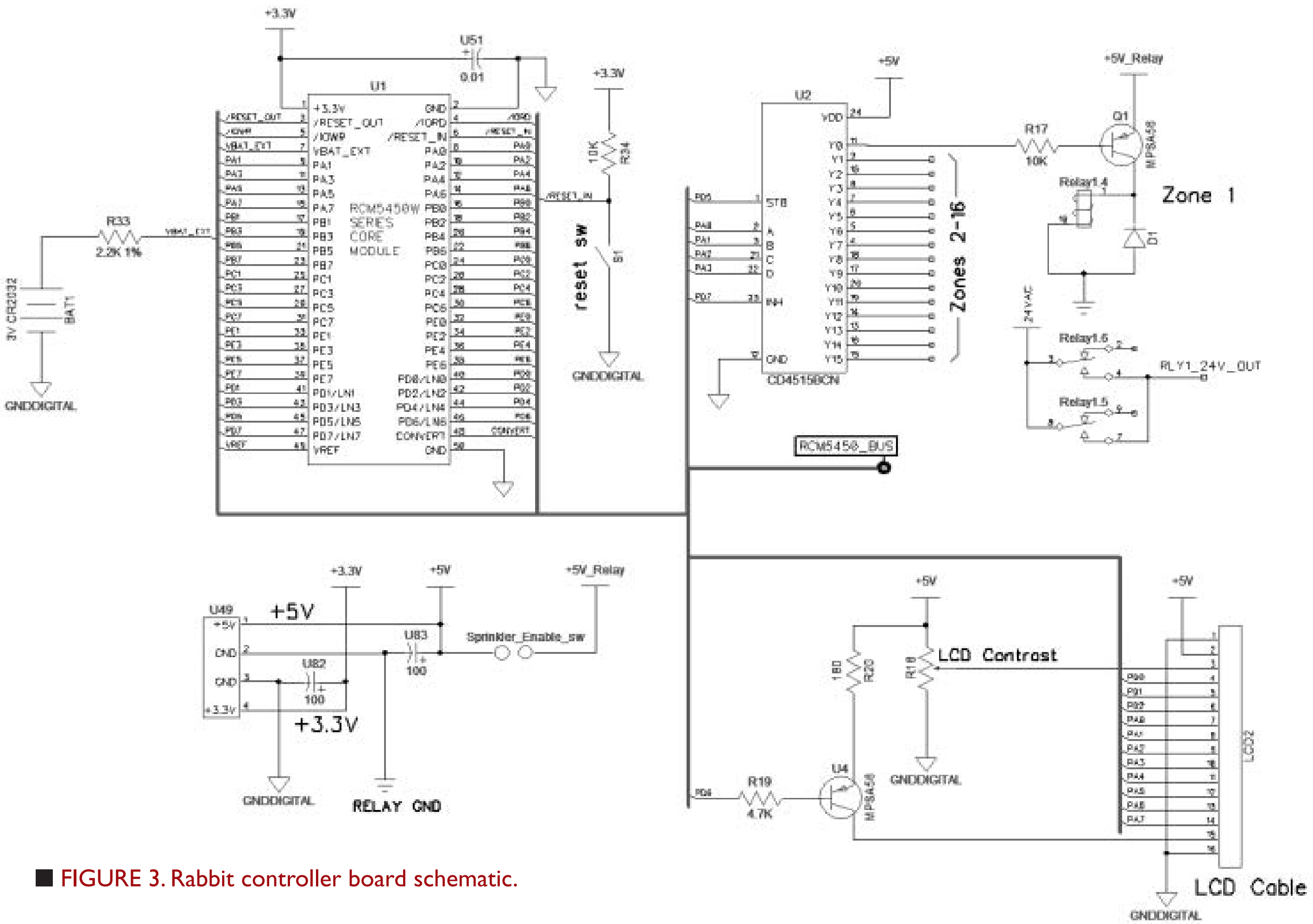
The base resistor R1 will have 0.5V on one end and +5V minus the 0.7V emitter/base drop on the other end. So, R = E/I = (5 – 0.7 – 0.5 volts) / 0.0005 amps = 7,600 ohms. I rounded that up to a convenient value of 10K.

What's that diode for? When the coil is energized, its

Why Rabbit and not Arduino?

I chose a Rabbit Semiconductor RCM5450W module for this project because I liked its features: it had a lot of I/O ports, it came with a large library of sample C code for doing all of the things I expected to do in this project, and Rabbit supplies a C compiler and development board for it. All I had to do was write the C code that would control the relay transistor drivers, plus the HTML that would run the Wi-Fi module's website. (That "all I had to do" was partly tongue-in-cheek; the code ended up being more of a challenge than I had expected. Isn't that true of most code, though?) The 802.11a/b/g wireless functionality was supplied by Rabbit — I changed the IP address to something suitable for my network; I set the wireless WEP key and network name to what I have at home; and added my code to Rabbit's sample code.

The RCM5450W modules aren't exactly cheap but they have 1 MB of Flash memory for the C code we will compile and download (of which my current download image uses 300K) and a relatively fast processor at 74 MHz (compared to Arduino's 16 MHz). If I were starting this project over today, I would look into the Arduino, but after a couple of years of experience I'm pretty happy with the Rabbit.



■ FIGURE 3. Rabbit controller board schematic.

magnetic field is holding the relay's switch contacts closed. When the coil current is cut off, that magnetic field collapses. As it does, it induces current in the coil which causes a reverse voltage to appear across the relay's coil. The magnitude of that voltage is proportional to how quickly the field collapses, and can be quite large. The diode provides a low impedance path into which the magnetic field's induced current can discharge.

The Wi-Fi Module Interface

There are 50 pins in the Rabbit module's connector. In the schematic in **Figure 3**, I chose to bundle all 50 into one bus — the "RCM5450_bus" — for the sake of easy and clear documentation.

One thing to beware: For some reason, Rabbit labels all the pins on one side of the module connector as even, and the other side carries all the odd pins. If you're used to normal IC package numberings, you'll be expecting the numbers to start with pin 1 at one corner, and sequentially number the rest around the package in a counterclockwise direction (looking down at the part).

Per Rabbit's documentation, there is a 3V battery backup connected through a 2.2K resistor. U51 is a standard decoupling capacitor. S1 is a momentary contact reset switch, and R34 pulls the reset pin to an inactive high level when S1 is not active. Two corner pins — 2 and 50 — are grounds, and pin 1 supplies +3.3V to the module.

If you are not familiar with "bus-style" schematics, that thick blue line that all of the pins seem to "connect to" does not imply that all of the signals are somehow connected together into one big fat (useless) blue wire. That thick blue line is just a convenient way of grouping all of the signals at the interface of the RCM5450W module so that we can pick out subsets of them for various uses in other schematic pages.

Interfacing to the Relay Drivers

Earlier I said we would take advantage of the fact that we will never want more than one zone on at a time. Here's where we do that — in the circuit that translates the module's port outputs into the 16 transistor relay driver signals.

The CD4515 chip is a 4:16 decoder with an output inhibit, plus a four-bit latch on its inputs. The 4515's four select inputs — A, B, C, and D — pick one of the 16 Y output pins to assert. I'm going to call this four-bit input "DCBA," because D is the most significant bit, and A is the least significant. If only the B bit is high and the other three are low, I'll show that as 0010, and it corresponds to a binary 2, meaning the Y2 output would be asserted. All non-selected outputs will remain high. Note that the Y

equals 6), thus Y6 will be low and all other Y outputs will be high. Also note that it is literally impossible to activate more than one zone at a time because the 4515 will only ever precisely do one of two possible things: it will assert no zones if the inhibit input is asserted, or it will assert whichever Y output corresponds to the four-bit pattern in its internal latch.

What's the purpose of the four-bit latch? Notice that I have used four of the PA bits from the RCM5450W module's Port A. I will also use those same bits to convey data to and from the LCD module. The 4515 lets me write the four bits into its internal latch; once the PA bits have been written into that latch, I can reuse PA bits for other things, such as changing the display on the LCD module so that the clock remains accurate.

I'm using PD5 as the latch enable. The protocol here is simple: To enable relay X, write the RCM5450W Port A bits 3:0 with the value of X. Then, write Port D bit 5 (which is normally a 0) to a 1, and then back to a 0. That causes the latch to open which passes X through to the 4:16 decoder, and then causes the latch to close which causes the latch to remember that value of X until next time.

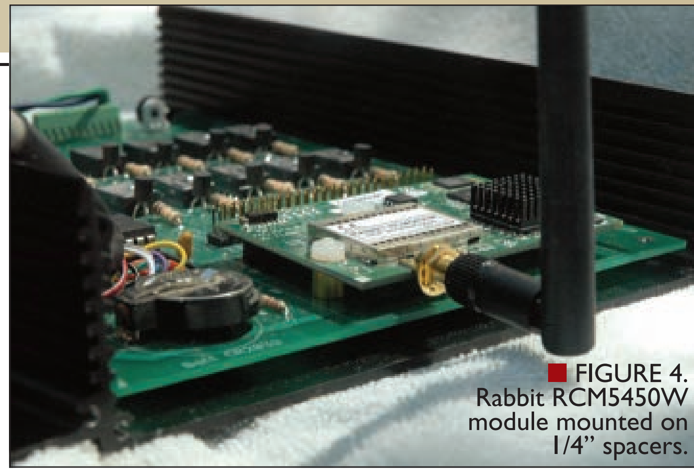
Meanwhile, PD7 has been held inactive all this time, so no Y outputs of the 4515 are asserted, and no relays are yet activated. Once the four-bit value is sent on Port A bits 3:0 and latched by pulsing PD5, we can de-assert the 4515's "INHIBIT" input by writing PD7 to zero, and keep it low for the duration of the sprinkling desired.

Interfacing to the LCD Module

The only semi-tricky part of interfacing to the LCD module is to find a way to accomplish that interface without interfering with the relay interface. Previously, I showed how the relay interface was done, using Port A bits 3:0 and Port D bits 5 and 7. If Port D bit 7 is high, then you can do anything you want to the Port A bits. The relays won't see it because the 4515 chip's outputs will not be enabled.

So, to interface to the LCD module, I used all eight Port A bits, plus some Port D bits for the three LCD control signals RS, E, and R/W. Note that the Port D control bits I chose were *not* the same ones I used for relay interfacing. The LCD module listens to Port D bits 2:0, plus bit 6 to control the LCD module backlight; the relay interface uses Port D bits 5 and 7. There are 16 pins on the LCD module. Pins 1 and 16 are grounded, and pin 2 supplies +5V. Pin 3 is a voltage between 0 and +5V - this voltage sets the display's contrast.

I assigned three Port D signals to control the LCD module: Port D bits 0, 1, and 2. PD0 is the module's RS bit, PD1 is R/W, and PD2 is the Enable bit.



■ FIGURE 4. Rabbit RCM5450W module mounted on 1/4" spacers.

The particular module I used has a switchable backlight, so I provided a transistor "relay driver" circuit to turn the backlight on and off. The only new element here is an additional resistor in the emitter leg of U8 which is there to limit the LED current for the LED backlight. LEDs drop approximately 2V while illuminated, and should be limited to less than 20 mA to avoid burnout; 5V – 2V – 0.1V (emitter-collector drop when transistor is on and saturated) = 2.9V. E=IR, so R = 2.9 volts/0.020 amps = 145 ohms. I upped this to 180 ohms for a safety margin. The base resistor limits the base current and was determined along similar lines. When the transistor is on, we want 20 mA in the collector, so we need at least 1/100th that much in the base, or 0.0002 amps. The transistor's emitter lead is at 5 – 2.9 = 2.1V. The emitter/base junction is 0.7V, so there are 2.1 – 0.7 volts at the base and 0.5V at the other end of the resistor which leaves 0.9V across the base resistor. Therefore, R = 0.9 volts/0.0002 amps = 4,500 ohms which I rounded up to 4.7K.

Power

There are three separate power supplies in this project: +3.3 VDC, +5 VDC, and 24 VAC. The +3.3V is for the Rabbit module; +5V is for the subminiature relays; and 24 VAC for the sprinkler valves. I found a cheap switching power supply for the +3.3 VDC and +5 VDC, and a 24 VAC transformer. Because four-pin power connectors are ubiquitous from their use in personal computers, I used one in this project. The two capacitors smooth DC ripple from the supplies and minimize problems from inductance in the wires of the four-wire cable coming from the power supplies. Notice that although two wires of the four-wire power cable are ground wires, I take care here to keep them electrically separated from one another. To accomplish this, they have different names. The noisy, relatively high current relay coil ground returns are labelled "Relay GND," while the Wi-Fi module and other logic use the "GNDDIGITAL" ground return. Only at the other end of the four-wire power cable do these ground wires get connected together.

The basic problem of sharing current paths is that these paths are not perfect. Even fat ground traces have small but not inconsequential resistance (R) and inductance (L), and the longer the shared path, the higher the induced noise from changes in current. By minimizing the sharing of any current paths between the coils and the logic, there is much less shared R and L and therefore much less induced noise seen by the logic. **NV**

continued from page 29

QUICKTURN PROTOTYPES IN AS LITTLE AS 24 HOURS

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SHOWCASE

■ BY FRED EADY

TIME FOR SOME RTCC TRANSLATING

Sprechen sie Deutsch? I don't, but I had to perform some cross-language code translation to gain the information necessary to write the code for this month's project. My cross-language translating does not involve BASIC to C. I'm talking about German to English source code translation.

***Achtung* is about all of the understandable German I can utter. However, I did manage to wade through some German source code and force my EA DOGM162L-A to speak English. Once we are able to get the dog to bark, we can start teaching it new tricks.**

PROBLEME MIT DER ANZEIGE DER ZEIT

My *problems with displaying time* started all of this confusion. Our goals this month are to write drivers for the EA DOGM162L-A LCD and the PIC18F47J53's hardware RTCC (Real Time Clock Calendar). The EA DOGM162L-A is based on the Sitronix ST7036 Dot Matrix LCD controller/driver. New number, same commands and mechanics as the ST7036 is HD44780 compatible.

The ST7036 datasheet offers an example initialization code snippet that is based on the saintly 8051 microcontroller. As you can see in **Listing 1**, the EA DOGM162L-A 8051 SPI initialization source code is written in assembler. However, we can easily pick out the timing calls and ST7036 register values which are all we're interested in anyway. The problem is that these timings don't work with an EA DOGM162L-A being driven by our (Universal Storage Control Module) USCM-47J53. With that, the search for answers begins.

After some exhaustive research, I ended up back in the *DOWNLOAD* area of the EA DOGM162L-A website. There's a download item there that I have been purposely avoiding. The downloadable serial source code driver is written in German and targets AVR microcontrollers. The AVR part of the code doesn't bother me as I know that I can easily port AVR mnemonics to PIC speak. Another problem with the German SPI driver source code can be seen in **Listing 2**. Notice that there are no carriage return and line feed characters in the listing. As Scooby would say, "WRUT WRO!"

Fortunately, keys in the German language listing such as *mS(50)*, *us(50)*, *void*, parenthesis pairs, and some English wording caught my eye. So, I dumped the contents of **Listing 2** into a NoteTab editor session and went to work. I began to try to add carriage returns and line feeds that would make the jungle of characters in **Listing 2** look like classic C source code. I also used

```
INITIAL_START:
        CALL HARDWARE_RESET
        CALL DELAY40mS
        MOV A,#38H ;FUNCTION SET
        CALL WRINS_NOCHK ;8 bit, N=1,5*7dot
        CALL DELAY30uS
        MOV A,#39H ;FUNCTION SET
        CALL WRINS_NOCHK ;8 bit,
        N=1,5*7dot,IS=1
        CALL DELAY30uS
        MOV A,#14H ;bias
        CALL WRINS_NOCHK
        CALL DELAY30uS
        MOV A,#78H ;Contrast set
        CALL WRINS_NOCHK
        CALL DELAY30uS
        MOV A,#5EH ;Power/ICON/Contrast control
        CALL WRINS_NOCHK
        CALL DELAY30uS
        MOV A,#6AH ;Follower control
        CALL WRINS_NOCHK
        CALL DELAY200mS ;for power stable
        MOV A,#0CH ;DISPLAY ON
        CALL WRINS_NOCHK
        CALL DELAY30uS
        MOV A,#01H ;CLEAR DISPLAY
        CALL WRINS_NOCHK
        CALL DELAY2mS
        MOV A,#06H ;ENTRY MODE SET
        CALL WRINS_NOCHK ;CURSOR MOVES TO RIGHT
        CALL DELAY30uS
```

■ **LISTING 1.** I figured since this code was part of the ST7036 datasheet, it was gospel. After all, the timings match the datasheet declarations.

■ LISTING 2. When I picked out the words *Cursor BLINKEN*, I knew that I could make some sense of this jumble of German-English source code.

```
/* ————————————————————————————————————- Sample
code for driving ST7036 on ELECTRONIC ASSEMBLY's
DOG-Series (tested on ATmega8, EA DOGM163, AVR-
GCC) *** NO FREE SUPPORT ON THIS PIECE OF CODE
*** if you need an offer: mailto:
programmer@demmel-m.de ——————————————————————————
—————————- */ //Serieller Betrieb von EA
DOGModulen mit dem ST7036 #define ST7036_SI
As_(PORTD, 5) #define ST7036_CLK As_(PORTC, 4)
#define ST7036_CSB As_(PORTD, 2) #define
ST7036_RS As_(PORTD, 3) #define ST7036_RESET
As_(PORTB, 1) /* ein Byte in das ???-Register
des ST7036 senden */ void ST7036_write_byte(
char data ) { signed char u8_zahl
```

semi-colons and C comment slashes (//) to delineate lines of Germanic source code. C source lines that began with *warten* or *warte* and ended with a semi-colon followed by a comment became prime targets as each source line contained a timing value. Consider this line of C source that I gleaned from the mass listing:

```
warten_ms(50); // mehr als 40ms
```

According to the **Listing 1** initialization source code, a 40 mS delay must be observed following a hardware reset. *Mehr als* is German for *more than* and *warten* means *wait*. So, the comment tells us to wait in excess of 40 mS and that advice is heeded by 10 mS in the actual code. The mnemonics shown in **Listing 1** instruct us to delay for 40 mS. If you compare the timing marks of **Listing 1** with **Listing 2**, you won't get very far. So, I've included this code snippet, which reads just a bit better than **Listing 2**:

```
void ST7036_init(void)
{
Set_Bit(ST7036_CLK);
Set_Bit(ST7036_CSB);
ST7036_reset();
warten_ms(50); // mehr als 40ms
ST7036_write_command_byte( 0x38 );
// Function set; 8 bit Datenlänge, 2 Zeilen
warten _us(50); // mehr als 26,3µs
ST7036_write_command_byte( 0x39 );
// Function set; 8 bit Datenlänge, 2 Zeilen,
// Instruction table 1
warte_us(50); // mehr als 26,3µs
warten ST7036_write_command_byte( 0x1d );
// Bias Set; BS 1/5; 3 zeiliges Display /1d
warte_us(50); // mehr als 26,3µs
warten ST7036_write_command_byte( 0x7c );
// Kontrast C3, C2, C1 setzen /7c
warte_us(50); // mehr als 26,3µs
warten ST7036_write_command_byte( 0x50 );
// Booster aus; Kontrast C5, C4 setzen /50
warte_us(50); // mehr als 26,3µs
warten ST7036_write_command_byte( 0x6c );
// Spannungsfolger und Verstärkung setzen /6c
warte_ms( 500 ); // mehr als 200ms warten !!!
ST7036_write_command_byte( 0x0f );
// Display EIN, Cursor EIN, Cursor BLINKEN /0f
warte_us(50); // mehr als 26,3µs
warten ST7036_write_command_byte( 0x01 );
// Display löschen, Cursor Home
warte_ms(400); //
ST7036_write_command_byte( 0x06 );
// Cursor Auto-Increment
warte_us(50); // mehr als 26,3µs warten }
```

The EA DOGM162L-A's CLK and CSB pins are driven to their inactive states and an ST7036 hardware reset is initiated. After the mandatory greater than 40 mS delay, the ST7036 initialization sequence begins. As you can see, the *ST7036_init* function follows along just like the example code in **Listing 1**. Let's apply these German timings and register settings to our USCM-47J53 SPI driver code.

CODING THE EA DOGM162L-A DRIVER

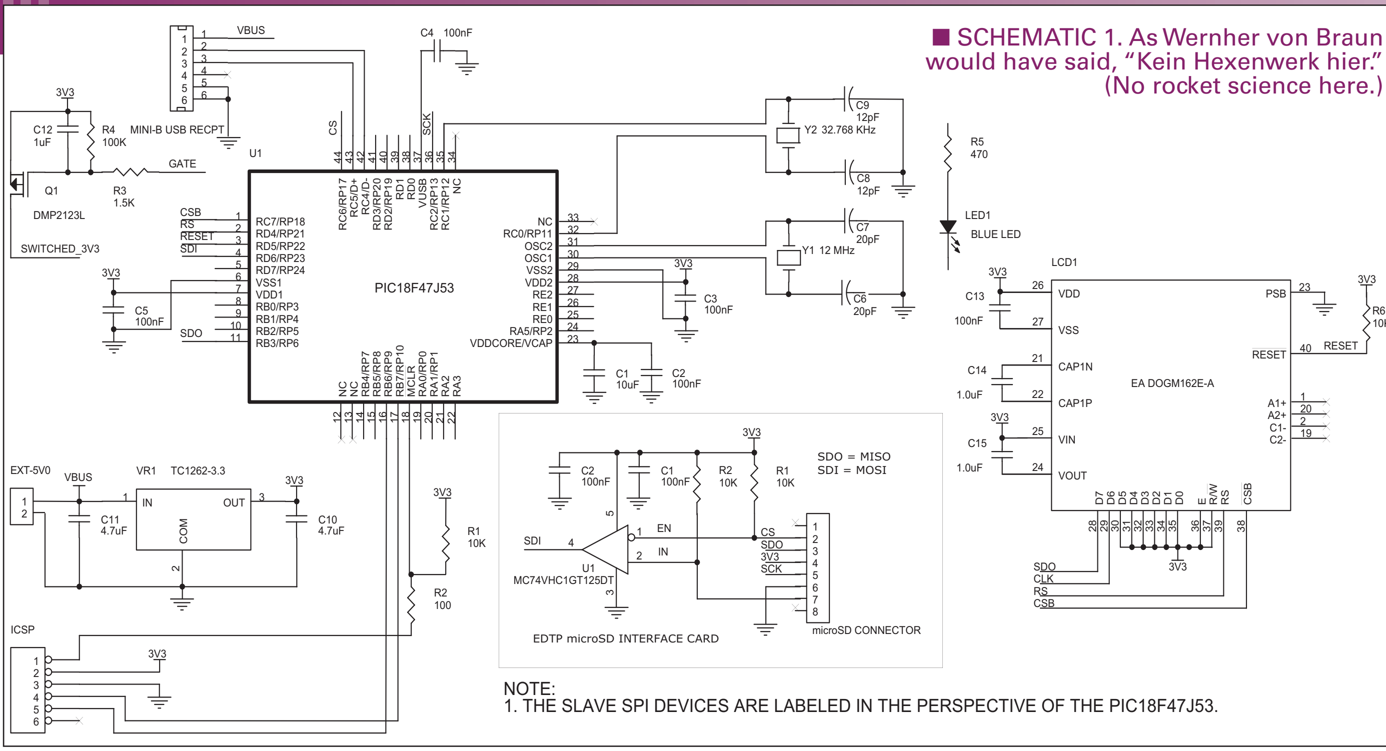
Before we can deliver bytes to the EA DOGM162L-A's SI pin, we must establish a Master SPI portal at the USCM-47J53 end of the proposition. To bring a Master SPI portal to life, we must first assign the SPI clock and data lines to appropriate pins on the PIC18F47J53. To begin the Master SPI portal initialization process, the peripheral pin select feature of the PIC18F47J53 must be unlocked which enables us to associate PIC18F47J53 Master SPI functions with multi-purpose PIC18F47J53 I/O pins:

```
//Initialize the SPI

   //  UnLock Registers
          EECON2 = 0x55;
          EECON2 = 0xAA;
          PPSCONbits.IOLOCK = 0;
   //  Unlock ends

   //  Pin Remapping
          RPOR6 = 10;
          //RP6 (RB3) as SDO2 (output pin)
          RPOR13 = 11;
          //RP13 (RC2) as SCK2 (output pin)
          RPINR21 = 23;
          //RP23 (RD6) as SDI2 (input pin)

   //  Pin Remapping ends

   //     Lock Registers
          EECON2 = 0x55;
          EECON2 = 0xAA;
          PPSCONbits.IOLOCK = 1;
   //  Lock Registers ends
```

If you're just joining us, we revealed the magic behind the SPI remapping process in the previous Design Cycle. Basically, remappable peripherals are selected via values placed in the peripheral pin select register set.

Once the Master SPI portal I/O pins are established, we must adjust their directions. For instance, CSB is an EA DOGM162L-A input pin and a corresponding output pin must be configured at the USCM-47J53 end. The coded pin assignments are echoed in **Schematic 1**:

```
#define EACSB        PORTCbits.RC7
       //EA DOGM162L-A CSB pin
#define EARS         PORTDbits.RD4
       //EA DOGM162L-A RS pin
#define EARESET      PORTDbits.RD5
       //EA DOGM162L-A RESET pin

#define OUTPUT_PIN    0
#define INPUT_PIN     1

TRISCbits.TRISC7 = OUTPUT_PIN;     //CSB
```



■ SCHEMATIC 1. As Wernher von Braun would have said, "Kein Hexenwerk hier." (No rocket science here.)

```
TRISDbits.TRISD4  = OUTPUT_PIN;      //RS
TRISDbits.TRISD5  = OUTPUT_PIN;      //RESET
TRISBbits.TRISB3  = OUTPUT_PIN;      //SDO2
TRISCbits.TRISC2  = OUTPUT_PIN;      //SCK2
TRISDbits.TRISD6  = INPUT_PIN;       //SDI2
```

As you can see, we also matched up the EA DOGM162L-A's control lines (CSB, RS, and RESET) with the appropriate PIC18F47J53 I/O pins and defined their data directions. The EA DOGM162L-A CSB pin resets the EA DOGM162L-A's internal SPI bit counter on its falling edge. As far as the RS pin is concerned, it performs the same command/data identification function as it does in parallel mode.

The EA DOGM162L-A's RESET pin does exactly what you think it does. It can be tied directly to VDD. However, if we want the USCM-47J53 to issue a hardware reset to the ST7036 — and we do — we must tie the its RESET line to VDD by way of a pull-up resistor and assign a PIC18F47J53 I/O pin to the RESET function. Again, **Schematic 1** reflects the EA DOGM162L-A RESET pin circuitry.

Normally, we would stuff the bits directly into the SPI SFR (Special Function Register) to initialize and configure the PIC18F47J53's Master SPI portal. The Microchip C18 C compiler comes equipped with library routines that take some of the bit twiddling tedium out of configuring PIC peripherals. For instance, by simply including *spi.h*, we can open and configure the SPI2 Master portal with this self-commenting line of code:

```
OpenSPI2(SPI_FOSC_64, MODE_11, SMPEND);
```

The first argument of the *OpenSPI2* library function sets the SPI clock speed. The SPI clock could be set up to run faster but through experimentation, I found that a SPI SCLK line clocked at Fosc/64 works best with the USCM-47J53's clocking system. The MODE selection indicates that the SCLK rest (inactive) polarity is logically high and that data is transferred on the active to inactive edge of SCLK. SMPEND (sample input at the end of data output time) is just a place holder here as the EA DOGM162L-A doesn't send any data in the SPI clock stream back to the Master SPI device.

Judging by the listings we've studied, it's pretty obvious that we'll need to code some delay routines. If we were writing our EA DOGM162L-A driver code using CCS C, that's a no-brainer as the CCS C compiler has built-in delay functions. The same holds true for the Microchip compiler. However, to take advantage of the C18 C compiler delay routines, we must include *TimeDelay.h*. Once we have the delay routines in place, we can call upon their functionality like this:

```
Delay10us(5)    = delay for 50uS
DelayMs(5)      = delay for 5mS
```

At this point, we have control of the PIC18F47J53's Master SPI portal and as Mick Jagger would say, "Time is on our side. Yes it is." At this point, we can assemble our EA DOGM162L-A SPI driver routines.

CODING THE EA DOGM162L-A SPI DRIVER

Basically, we need to send commands and data to the EA DOGM162L-A's SI pin via the PIC18F47J53's Master SPI portal SDO2 pin. Much of our coding work has been done for us within the C18 SPI library. However, to activate the LCD, there are procedures that must be followed in order within our EA DOGM162L-A SPI driver routines.

No matter if the SPI bit stream is carrying a command or byte of data, the EA DOGM162L-A's CSB pin must be

driven low before any bits are clocked out of the Master SPI portal's SDO2 pin. Once the EA DOGM162L-A's bit counter is reset by the falling edge of the CSB signal, the RS pin must be conditioned to inform the EA DOGM162L-A about the type of data it is about to receive. A command is transmitted when the EA DOGM162L-A's RS pin is driven logically low. Data is clocked out of the SDO2 pin when the EA DOGM162L-A's RS pin is driven logically high. With that, we can code the following core driver routines:

```
//**********************************************
//* SEND LCD COMMAND VIA SPI
//**********************************************
void spi_cmd(char cmd)
{
        EACSB = 0;
        EARS = 0;
        WriteSPI2(cmd);
        EACSB = 1;
        DelayMs(2);
}
//**********************************************
//* SEND LCD DATA VIA SPI
//**********************************************
void spi_data(char data)
{
        EACSB = 0;
        EARS = 1;
        WriteSPI2(data);
        EACSB = 1;
        DelayMs(2);
}
```

Note that the CSB pin's fall to logically low and rise to logically high encapsulate the bit transmission in both the command and data transmission routines. The *WriteSPI2* function is provided by the C18 SPI library, which we included into our application (#include "spi.h"). The inclusion of the C18 delay library routines (#include "TimeDelay.h") takes care of the 2 mS delays at the end of each of our bit transfer routines.

The *spi_data* and *spi_cmd* functions form the basis for our EA DOGM162L-A SPI driver set. For instance, our little *spi_cmd* function is the pivot point for our *spi_gotoxy* driver function:

```
void spi_gotoxy( char x, char y)
{
// where x = lcd row (1,2,3,4) and
// y = column (1 thru 20)
   char address;
   switch (x)
   {
       case 1:
          address = 0;      //line 1
          break;
       case 2:
          address = 0x40;   //line 2
          break;
       case 3:
          address = 0x14;   //line 3
          break;
       case 4:
          address = 0x54;   //line 4
          break;
       default:
          address = 0;
   }
   address += (y-1);
   spi_cmd(0x80|address);   //set DDRAM address
}
```

It's like the old axiom that states "Where there's smoke, there's fire." In our case, "Where there's a function, there's a macro." We can spin the *spi_gotoxy* driver and *spi_cmd* functions into a trio of EA DOGM162L-A driver macros:

```
#define lcdcls       spi_cmd(0x01)
//clear the LCD macro
#define line1        spi_gotoxy(1,1)
//goto line 1 LCD macro
#define line2        spi_gotoxy(2,1)
//goto line 2 LCD macro
```

The USCM-47J53 operates in a round-robin environment. That means that the PIC18F47J53 is servicing a USB port as well as the EA DOGM162L-A LCD, plus other various tasks. So, we have to build our EA DOGM162L-A driver to step into and step out of the round-robin queue as quickly as possible. To accomplish this, we will use an LCD text holding area (LCDText[]) that is emptied only when its turn comes around in the queue. The text holding area is a simple ASCII array that is loaded by the user and dumps its text to the EA DOGM162L-A with a cue from the *update* flag:

```
void spi_update(void)
{
   char i, j;

   // Go home
   line1;

   // Output first line
   for(i = 0; i < 16u; i++)
   {
       // Erase the rest of the line if a null
       // char is encountered (good for printing
       // strings directly)
       if(LCDText[i] == 0u)
       {
              for(j=i; j < 16u; j++)
              {
                     LCDText[j] = ' ';
              }
       }
       spi_data(LCDText[i]);
}

   // Set the address to the second line
   line2;

   // Output second line
   for(i = 16; i < 32u; i++)
   {
       // Erase the rest of the line if a null
       // char is encountered (good for printing
       // strings directly)
       if(LCDText[i] == 0u)
       {
              for(j=i; j < 32u; j++)
              {
                     LCDText[j] = ' ';
              }
       }
       spi_data(LCDText[i]);
   }
   flags.update = 0;
}
```

The *spi_update* function is a modified version of the generic parallel LCD driver that comes with the Microchip application libraries. The results of the modified version are the same as the original routine with the exception of the bits being driven over a SPI portal via our *spi_data* routine. Here's all we need to do to put a message on the EA DOGM162L-A glass:

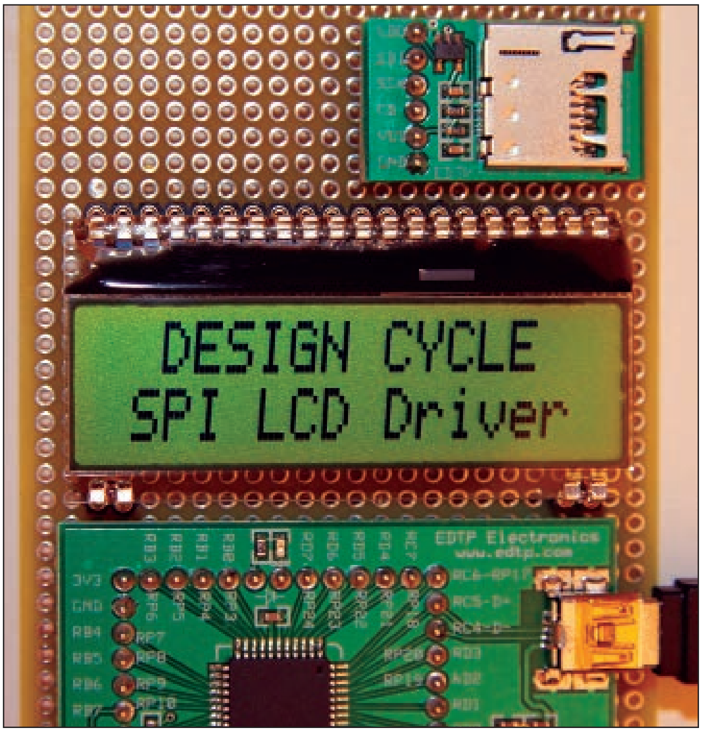
```
//Display Character position
 12345678123456781234567812345678
char lcdmsg_dc[]              =
"  DESIGN CYCLE   SPI LCD Driver ";
       for(x=0;x<sizeof(lcdmsg_dc);++x)
              LCDText[x] = lcdmsg_dc[x];

       flags.update = 1;
```

The dog is barking and standing on its hind legs in **Photo 1**. Note that the *spi_update* driver routine automatically divides the LCDText array contents into a pair of 16 character lines. The USB connection is a bit more than a power source as the USCM-47J53 has enumerated and clocked in as a HID class device with the host laptop.

TIME IS ON MY SIDE

The PIC18F47J53 is equipped with a full-monty RTCC. In addition to keeping time and date, the PIC18F47J53's RTCC contains alarm capability. All we need to make the PIC18F47J53's real-time clock calendar tick is a clock source and a little bit of code.

■ **PHOTO 1.** The USCM-47J53 is running in USB HID mode and has enumerated with the Lenovo laptop host. Thus, we could spin up some laptop-side and USCM-47J53-side code to display characters under the control of incoming HID report packets.



The USCM-47J53 has pad area to support a Fox FX135 SMT 32.768 KHz crystal. The FX135 is the missing link in the PIC18F47J53's TIMER1 oscillator chain. The ticks generated by the TIMER1 oscillator produce time keeping in years, months, days, day of the week, hours, minutes, seconds, and half seconds. The trick is loading the date/time registers and picking out the date/time data that your application requires.

The PIC18F47J53 datasheet is rather detailed when it comes to the description of the operation of the real-time clock calendar. However, it all boils down to a few "must do" operations and an understanding of where the time/date data resides. One other important fact you need to know is that the time/date data is stored within the RTCC as BCD digits.

Two bits form a pointer to the date/time data within the RTCC. **Table 1** is representative of how the date/time data is arranged. To write to the HOURS byte, set the RCTPTR bits to 01 and load the data to RTCVALL. Whether you use the WEEKDAY byte or not, you must write to it if you want the RTCC innards to automatically move to the SECONDS byte. Otherwise, you would have to reload the RTCPTR bits to point at the byte set you desire to manipulate. The RCTPTR bit set will decrement after every access to the RTCVALH register. Once the RCTPTR bits reach 00, they will stay there until the user resets them. Writes to the date/time array are controlled by the RTCWREN bit which must be set to allow writes to the date/time array.

Configuring the PIC18F47J53's RTCC begins with the configuration fuse settings:

```
#pragma config RTCOSC = T1OSCREF
//RTCC uses T1OSC/T1CKI as clock
```

Our application employs the preferred external 32.768 kHz crystal controlled clock. However, the PIC18F47J53's internal RC clock can also be used as a timing source. In that we're using the Timer1 oscillator option, we must also make sure that Timer1 is activated:

```
// Initialize the RTCC
     T1CONbits.TMR1CS1 = 1; //clock source is
                            //T1OSC
     T1CONbits.TMR1CS0 = 0; //
     T1CONbits.T1OSCEN = 1; //power up the T1OSC
                            //crystal driver
     T1CONbits.TMR1ON = 1;  //start TIMER1
```

The next step in getting the RTCC up and running involves unlocking the date/time array for write operations. The PIC18F47J53 datasheet provides a recommended method that involves writing a 0x55/0xAA sequence before setting the RTCWREN write lock bit:

```
EECON2 = 0x55;
EECON2 = 0xAA;
RTCCFGbits.RTCWREN = 1;
```

With the write lock removed, we can now enable the RTCC and write to the date/time array:

```
RTCCFGbits.RTCEN = 1;
RTCCFGbits.RTCPTR1 = 0;
RTCCFGbits.RTCPTR0 = 1;
RTCVALL = 0x23;           //HOURS
RTCVALH = 0x00;           //WEEKDAY
RTCVALL = 0x59;           //SECONDS
RTCVALH = 0x59;           //MINUTES
```

Note that I have set the RTCPRT bit pair to point at the WEEKDAY/HOURS registers. When we pass by the MINUTES set instruction, the date/time array holds time data only with a value of 23:59:59. The WEEKDAY value is set for Sunday (0). It is recommended that we write lock the date/time array after finishing the required write operations:

```
EECON2 = 0x55;
EECON2 = 0xAA;
RTCCFGbits.RTCWREN = 0;
prev_secs = 0x30;
```

The clock is running. We can pipe the time to our EA DOGM162L-A LCD using our *spi_update* function coupled with a new function that retrieves and converts the raw date/time for use by the LCD:

```
void get_bcd(unsigned char data)
{
   hibyte = ((data & 0xF0) >> 4) + 0x30;
   lobyte = (data & 0x0F) + 0x30;
}
```

All we need to do is add 0x30 to each RTCVAL to convert the RTCC's BCD data to display-able ASCII. To display the time every second, I've added the *prev_secs* variable. The *prev_secs* value is compared to the latest retrieved SECONDS value with every pass through the round-robin task queue. When the values don't match, the *spi_udate* function is triggered and all of the date/time information that has been stuffed into the LCDText array is displayed. Let's walk through the process beginning with setting the RTCPTR pointer bits:

```
RTCCFGbits.RTCPTR1 = 0;     //point to HOURS
RTCCFGbits.RTCPTR0 = 1;
```

Using our new get_bcd driver function, we are in the position to access and read the HOURS value:

```
get_bcd(RTCVALL);           //get HOURS
LCDText[0] = hibyte;
LCDText[1] = lobyte;
LCDText[2] = ':';
```

The HOURS bytes are read and stuffed into the LCDText array. Rather than reload the RTCPTR bits, we'll read the WEEKDAY value and simply ignore it:

```
get_bcd(RTCVALH);     //get WEEKDAY and ignore
```

Reading the WEEKDAY automatically decrements the RTCPTR bit pair and places us in the position to read the SECONDS value. Note that we "ignored" the WEEKDAY value by not saving the value into the LCDText array.

Following the SECONDS value acquisition, we perform the display test on the 1's value of the SECONDS ASCII bytes. If the values don't match, the time will be updated on the LCD in the next round-robin task pass. Meanwhile, we stuff the current SECONDS value into the LCDText array for display:

```
get_bcd(RTCVALL);           //get SECONDS
if(prev_secs != lobyte)
{
                      prev_secs = lobyte;
                      flags.update = 1;
}
LCDText[6] = hibyte;
LCDText[7] = lobyte;
LCDText[5] = ':';
```

Since we obtain the SECONDS value before we acquire the MINUTES value, we must adjust the position of the MINUTES and SECONDS values in the LCDText array. This is easily done with the LCDText array pointer values:

```
get_bcd(RTCVALH);    //get MINUTES
LCDText[3] = hibyte;
LCDText[4] = lobyte;
```

We can use the second line of the LCD to display anything we wish. In this instance, I've elected to clear the rest of the LCD by writing NULL characters to the remaining DDRAM locations:

```
for(y=8;y<33;++y)    //clear the rest of the LCD
   LCDText[y] = 0;
```

On the next pass through the *ProcessIO* function, the state of the update flag will determine if a new time value will be displayed on the EA DOGM162L-A's glass:

```
if(flags.update)
{
       spi_update();
}
```

YET IT IS

Photo 2 is proof that we followed the rules of the

■ **TABLE 1.** The trick is to set the RT CPTR value and load or read the least significant byte first.

RTCPTR<1:0>	RTCC Value Register Window	
	RTCVAL<15:8>	RTCVAL<7:0>
00	MINUTES	SECONDS
01	WEEKDAY	HOURS
10	MONTH	DAY
11	—	YEAR

RTCC to the letter. The application frameset we've used today is based on the HID model. We can just as easily run the EA DOGM162L-A and USCM-47J53 as a CDC device which forces the USCM-47J53's USB portal to emulate a standard RS-232 portal. Taking it one step further, the microSD card can be activated for instant mass data storage capability.

I'll end this edition of Design Cycle with the bridge of Mick's song ... hopefully, "You'll Come Running Back" for more next month. **NV**

SOURCES

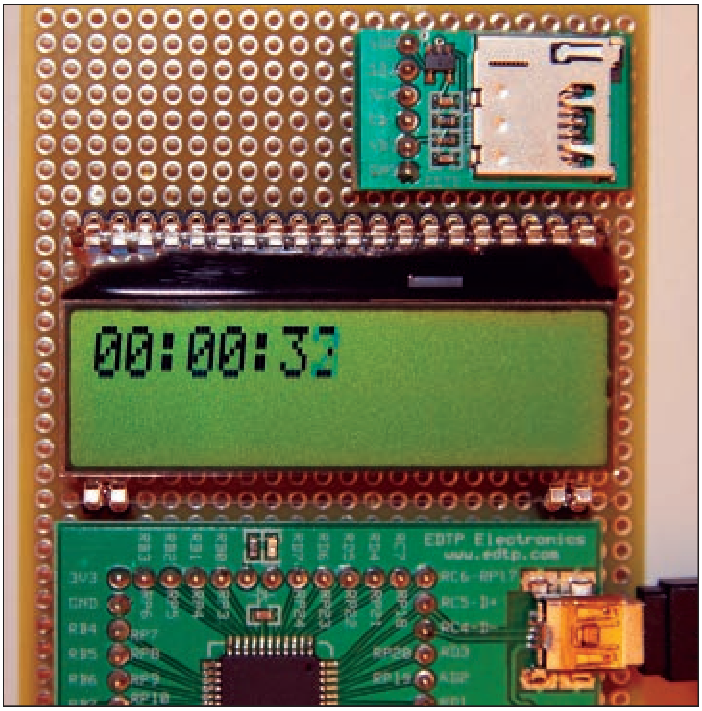
Mouser Electronics
EA DOGM162L-A
www.mouser.com

Microchip
Microchip C18 C Compiler
Microchip Application Libraries
PIC18F47J53
www.microchip.com

EDTP Electronics, Inc.
USCM-47J53
www.edtp.com

Fred Eady can be reached at fred@edtp.com.

■ **PHOTO 2.** The high intensity light emitted by my Flash boxes wiped out the display pixels and so did the standard camera flash. Fortunately, the camera is fast enough to catch the pixels before they disappear. What you see here is the display rolling over between 32 and 33 seconds just as the flash popped.

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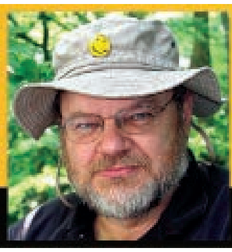


Follow along with this series! Joe's book & kits are available at www.nutsvolts.com

AVR_Toolbox — Documentation and Libraries

by Joe Pardue

■ FIGURE 1. AVR_Toolbox.

Recap

Last month, we learned more about SPI (Serial Peripheral Interface) and how to use it with the AVR Butterfly's 4 Mbit DataFlash. I ended that article with the promise that this month we would use the Butterfly DataFlash in a data logger application. However, then reality smacked me up side the head and I realized that we were getting into fairly complex stuff without having discussed some of the background concepts we will need to understand to keep from getting too confused.

A data logger uses just about everything that a microcontroller can do. We will be using the DataFlash to log the data, the hardware SPI to talk to the DataFlash, the USART to talk with a PC, one of the timers for a real time clock, the ADC for light, temperature, and voltage sensors, and other things that escape me at the moment. The point is that without some higher level of organization, this project will get out of hand. So, this month we will begin to build resources that we will use later to make that promised data logger.

I Left It Around Here Somewhere ...

Up to now, we've been pretty much dealing with only a few things at a time. For instance, when we examined AVR memory we divided it up into five articles where we learned about each type of memory and wrote some code that let us use each type. In the last two articles, we learned to access external memory in the Butterfly's Atmel DataFlash using the SPI bus (with hardware and software versions — and as a side benefit, we built a new light chaser LED project that had nothing to do with memory). So now, with all these great simple projects under your belt, you can easily recall all that you learned and immediately write the code — right? Well, if you can, you've got a better memory than I do.

I wrote the stuff and can't rewrite it from memory, and to make matters worse, I often can't even find where I left the working code. Smiley's Workshop is like a typical real workshop: It is very messy. In a real workshop, you'll be puttering along with a project and remember that you need to use a widget similar to one you built a few month's ago, so you go looking for it and hours later you find it under a pile of other widgets gathering dust in a corner. [And, yes the laws of nature work here — it really is the last place you'd think to look.] So you dust it off, build a copy of it, attach it to your project, and then realize AGAIN that for the *next* step you need another widget just like one you built several months ago. And darned, if you didn't see it when you were looking just now ... but where? And off you go again.

AVR_Toolbox

What we really need is a well organized toolbox for

all our stuff. Please note that I said 'we' — yes, you and me! Because of the miracle of the Internet, we will be able to use the same toolbox. The AVR_Toolbox (metaphorically shown in **Figure 1**) is an open source project hosted on Google Code [**http://code.google.com/p/avrtoolbox/**] where you will be able to access all sorts of AVR tools discussed in Smiley's Workshops. Anyone can download the code and since this is a "we" project, if you want to participate (and aren't crazy), I'd be happy (even grateful) for your help. I especially need feedback on typos and bugs, so if you see any problems, be sure and post something in the 'issues' page. AVR_Toolbox is a work in progress and always will be. We expect to get better with time; likewise, we expect our tools to get better.

Documenting With Doxygen

Doxygen [**http://www.stack.nl/~dimitri/doxygen/**] is a software documentation system that helps you write comments in your source code that can be scanned to produce documents in a variety of formats; most relevant here are HTML (shown in **Figure 2**) and Windows Help files (.html and .chm). Doxygen can do a lot of stuff and the AVR_Toolbox documentation is only one way to do things — one way that might evolve over time as we learn more about it.

One good reason to use doxygen is that it allows us to keep the documentation in one place tied directly to the source code. If we change the code, we've got the documentation right there in the code, making it easy to change it also. If you keep your documents in a separate manual and you make a change in the code, you'll write a note to yourself to remember to change the manual and then (if you're like me) you'll lose the note. With doxygen, you can even keep a to-do list directly linked to the code (shown in **Figure 8**).

Since we discussed the SPI last month, we will convert those functions into a library that we will document with doxygen to illustrate the principles involved. First, we create the documentation for our main page using the doxygen \mainpage directive:

■ FIGURE 2. Doxygen generated HTML main page.

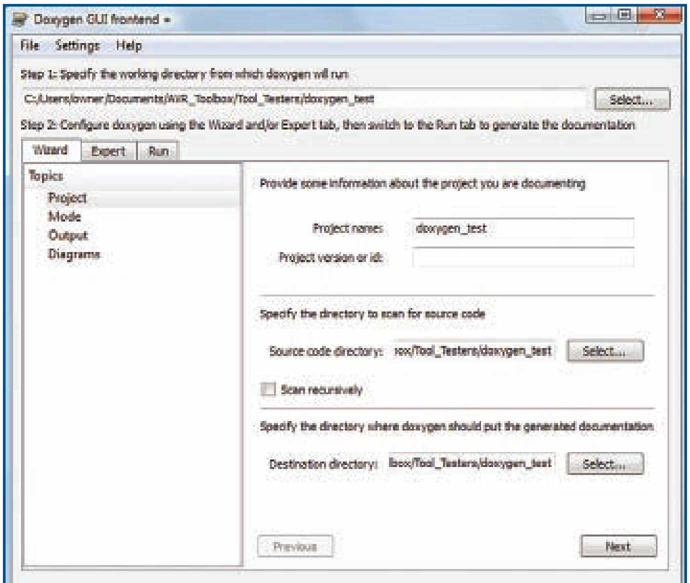
```
/*!
\image html AVR_Toolbox.gif

<center>Visit us at: http://www.smileymicros.com
</center>

\mainpage SPI (Serial Peripheral Interface)

This code was designed to allow the user to
create multiple SPI links using either bit-
banged software or regular AVR hardware SPI.

The user first selects a SPI number from a list
that can be expanded as needed:
#define SPI0
//#define SPI1
//#define SPIx // place holder

After selecting and SPI number, then the user
selects either software or hardware for that
number:
//#define SPI0_SOFT
#define SPI0_HARD

The user accesses the following functions:\n
void spi0_init_master(void);\n
uint8_t spi0_master_rw8(uint8_t to_slave);\n
uint16_t spi0_master_rw16(uint16_t to_slave);\n

Which are alia's for the software or hardware
version.

This code was tested for SPI0 in both software
and hardware modes on the ATmega169, ATmega328,
and ATmega644 (TODO)

\todo 1. Test it for the ATmega644.
\todo 2. Retest with the Arduino board.
\todo 3. Improve the comments before letting
this puppy loose!

\author Joe Pardue
\date October 29, 2010
*/
```

Doxygen will find this section and turn it into an html file that looks like **Figure 2**.

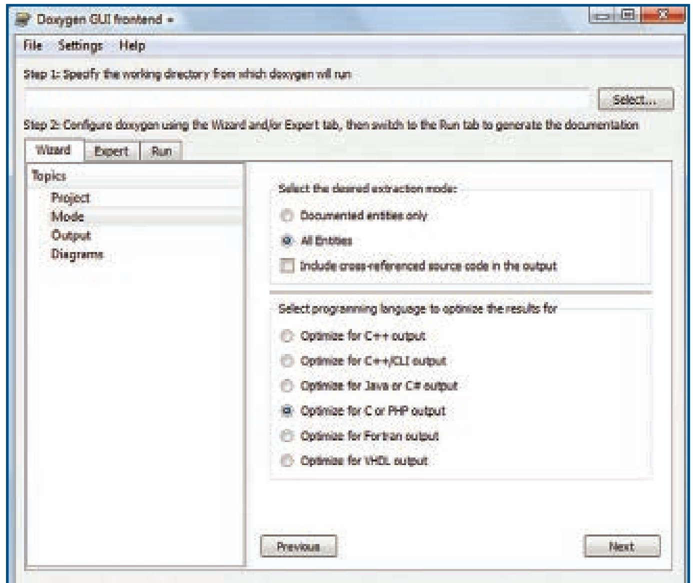
The first thing to notice about the code is that the section we want doxygen to look at is delimited with /*! and */. Most of the doxygen commands use a backslash ('\') character such as \mainpage. There are many doxygen commands, but we will only use a small subset of them to keep things simple. [The source code file is in the Workshop30.zip available from *Nuts & Volts*.]

Using Doxygen

After you install doxygen, you will find doxywizard.exe



■ FIGURE 3. Doxywizard project.



■ FIGURE 4. Doxywizard mode.

in the bin file. This application provides a GUI front-end for doxygen that helps simplify using it. Open it and fill out the project information as shown in **Figure 3**. In our case, we will be creating html documentation for the SPI functions in doxygen_test [in Workshop30.zip].

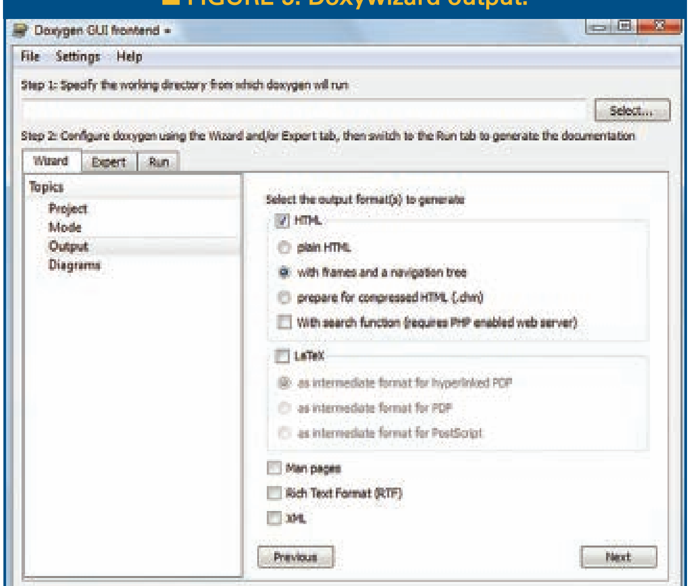
Click Next and set the mode as shown in **Figure 4**. Click Next again, and set the output as shown in **Figure 5**.

Click Next, but skip the Diagrams and you get what you see in **Figure 6** where you will click on the 'Run doxygen' and doxygen will generate your html files. Clicking on 'Show HTML output' will open your default browser with the files as shown in **Figure 2**. After you have finished playing with doxygen and are ready to close it, it will ask if you want to save the configuration file 'Doxyfile' – which you do. So, save it along with the rest of your project and then if you want to change anything, the next time you run doxygen you can use the File menu to open the existing Doxyfile, and save time filling in the wizard boxes.

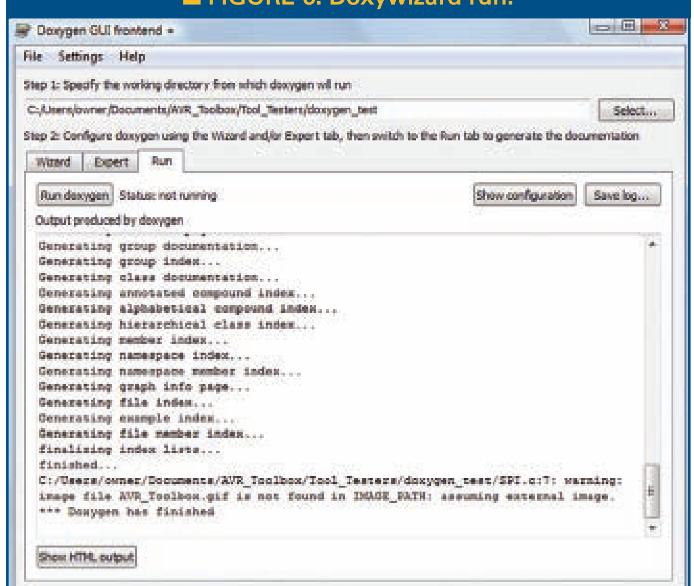
Looking At The Doxygen Generated Output

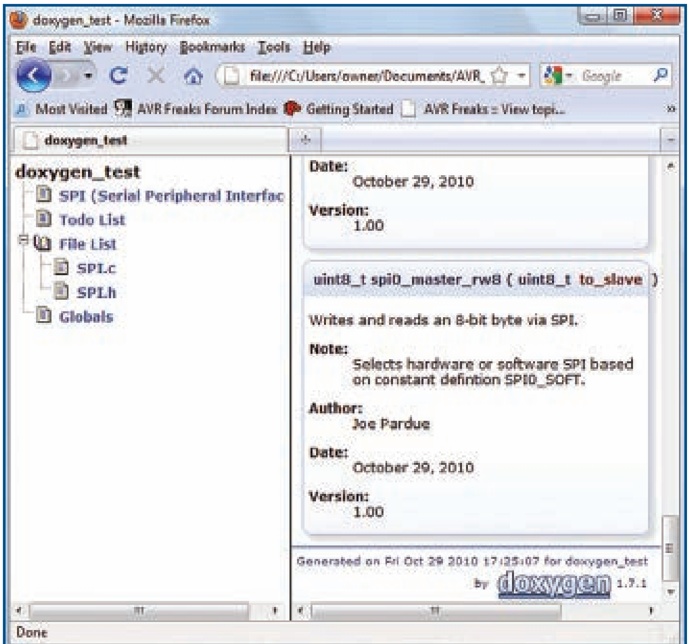
Quite frankly, I was shocked the first time I ran through this because the doxygen generated output document looks surprisingly good. It makes you want to go back to the code and spiff it up a bit just so it won't be embarrassed to be seen with such classy documentation. You've seen the main page in **Figure 2**, so play with it a bit to see what you've really got. In the frame on the left, click on the SPI file and you'll see the functions listed as

■ FIGURE 5. Doxywizard output.

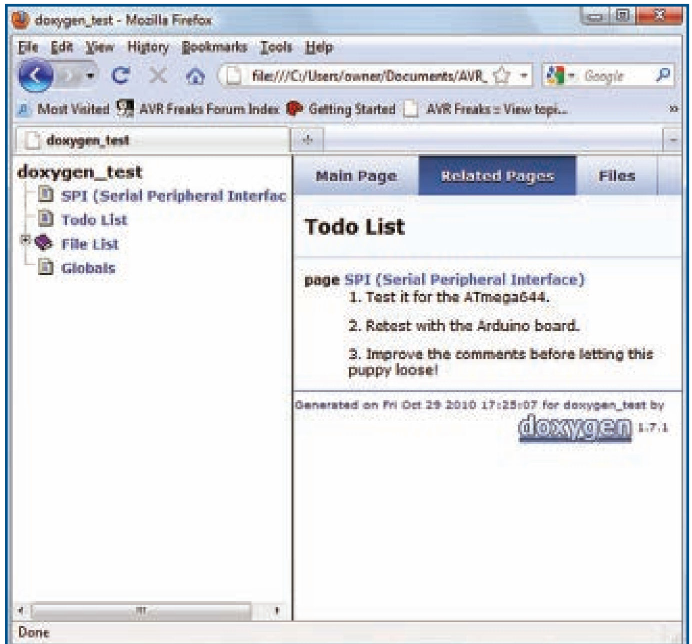


■ FIGURE 6. Doxywizard run.





■ FIGURE 7. Doxygen generated SPI function.



■ FIGURE 8. Doxygen generated Todo list.

shown in **Figure 7**. Click on the Todo List and you'll get what's shown in **Figure 8**.

As we progress with developing our AVR Tools library, we will add a few more doxygen features to the process, keeping in mind that our goal is to make the code documenting process as simple and easy as possible ***so we will use it***, but with just enough features to make the output really useful.

Converting To The HTML Help .chm File

You will notice that the HTML output is about 40 files and that you need to click on index.html to open the browser to access them. You can convert these files into a single compressed HTML (.chm) file (such as the typical Microsoft Help file shown in **Figure 12**).

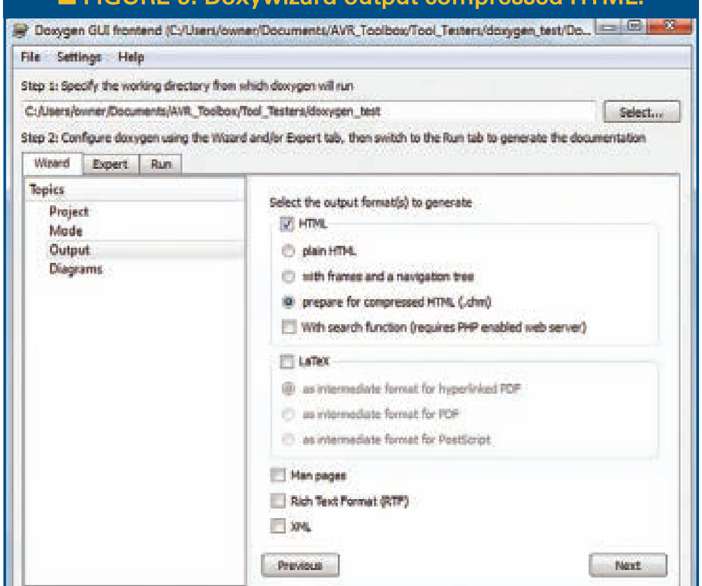
Set Doxygen to prepare the HTML output for compressed HTML (.chm) by selecting what's shown in **Figure 9**, then run it to create the file.

Download Microsoft HTML Help Workshop from **http://msdn.microsoft.com/en-us/library/ms669985.aspx**. Open HTML Help Workshop and click 'File\Open,' then browse to select the index.hhp generated by Doxygen which will fill out the IDE as shown in **Figure 10**.

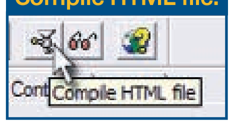
Click on the 'Compile HTML file' button as shown in **Figure 11**. The results will be index.chm. Change the name to doxygen_test.chm and click on it to reveal the help file shown in **Figure 12**.

You will probably want to

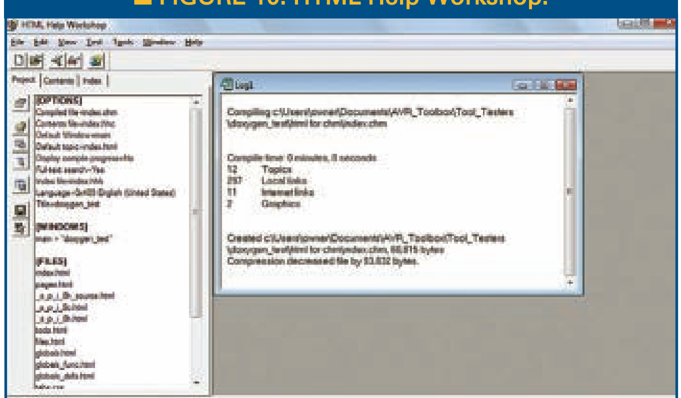
■ FIGURE 9. Doxywizard output compressed HTML.

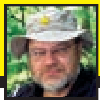


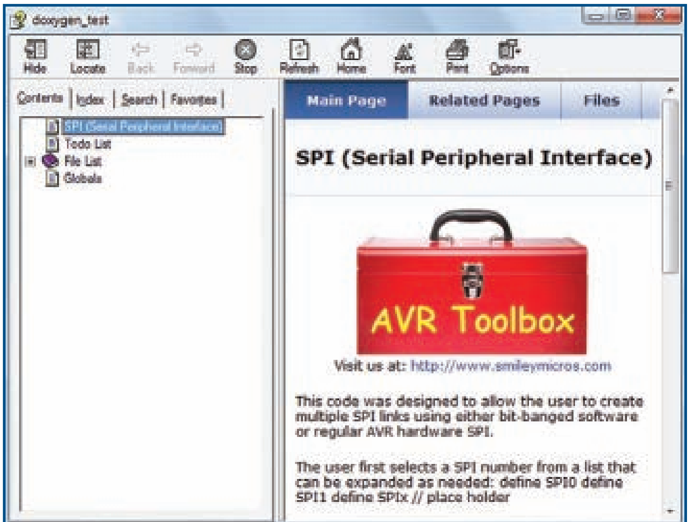
■ FIGURE 11. Compile HTML file.



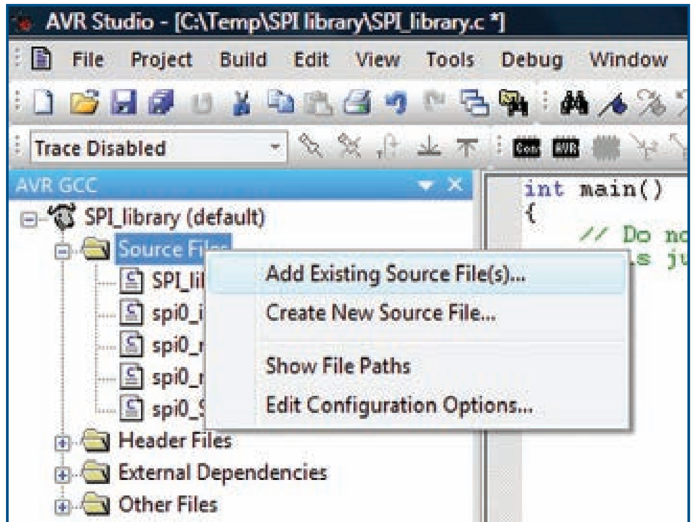
■ FIGURE 10. HTML Help Workshop.





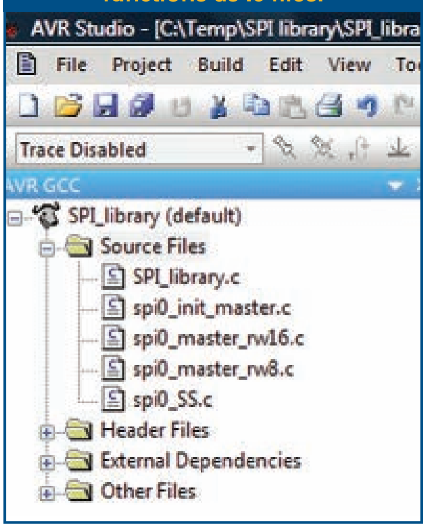


■ FIGURE 12. Doxygen_test compressed HTML Help file.



■ FIGURE 13. Add the .c files.

■ FIGURE 14. Individual functions as .c files.



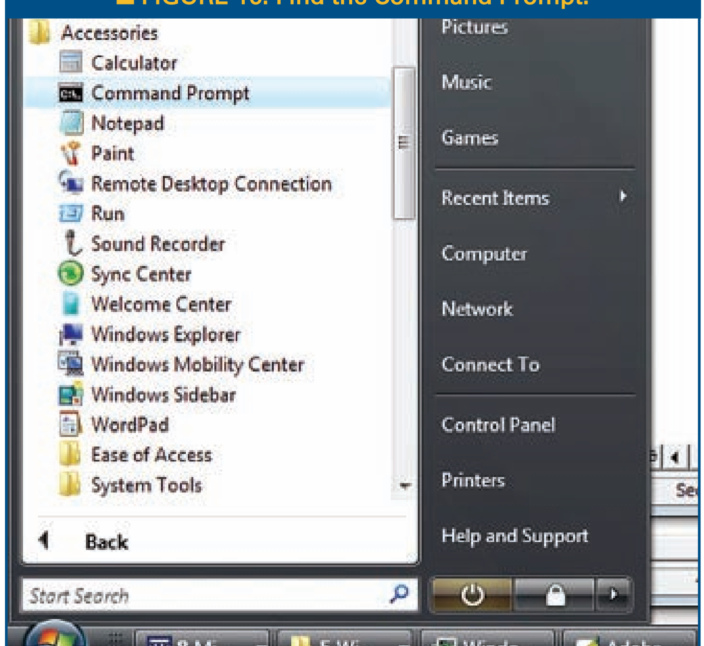
expand this to full screen. This has the same information in it as the HTML files generated earlier, but it is now all in one file (half the size of the original html) and the Help format provides some search options not available viewing the HTML version in a browser.

You now have one simple way to generate documents for your source code and you have an introduction to a tool (doxygen) that has many other features you may want to explore.

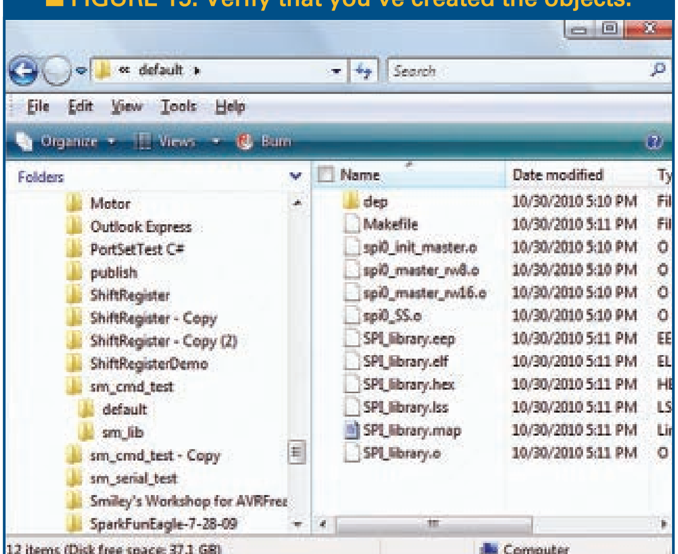
Libraries

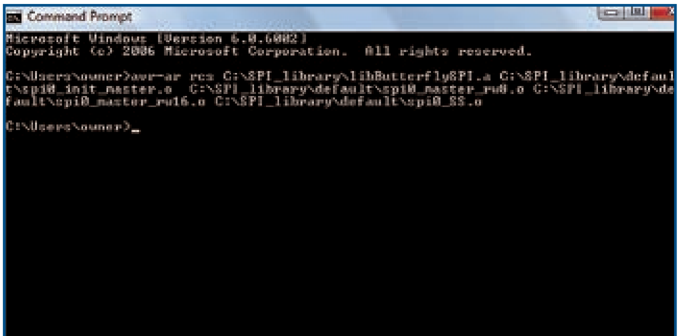
It might seem logical to keep a bunch of related functions in a single text file like we do with SPI.c that we used for our doxygen test. However, there is a problem with this in that when we write a program that only uses a few of the SPI functions, if we include the entire SPI.c file, the compiler will create a single object module for it and all the functions whether used or not will get linked into our program, increasing our code size unnecessarily. We don't want that. We want to

■ FIGURE 16. Find the Command Prompt.



■ FIGURE 15. Verify that you've created the objects.





■ FIGURE 17. Run avr-ar in the Command Prompt.

keep the code as small as possible and only link to the functions we will use. In order to do this, we will put each function into a separate file and compile each function into an object module that we will then put in a library. The linker will scan the library to find only the functions that are used in the code. Since we are going to be using the AVR Butterfly for our data logger, we will use a Butterfly specific subset of the SPI functions discussed last month, and put them into a special Butterfly SPI library.

Let's do this cookbook style. First, we extract the SPI functions that we want to use with the Butterfly into four separate .c files: spi0_init_master.c, spi0_master_rew16.c, spi0_master_rw8.c, and spi0_SS.c. Then, we add them to an AVRStudio project SPI_Library as shown in **Figures 13** and **14**.

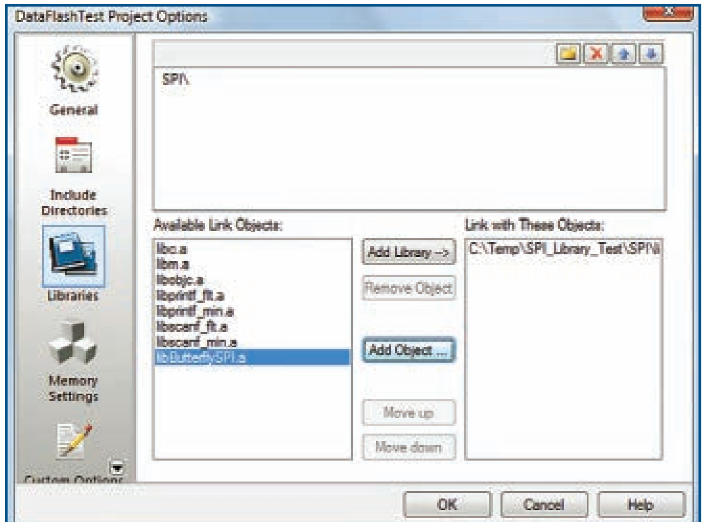
Next, we add the main.c file that, in this case, does nothing:

```
int main()
{
  // Do nothing since this
program
  // is just to create the
objects
}
```

Run the compiler and you will generate the object modules for each of the .c files that will be located in the \default directory as shown in **Figure 15**.

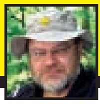
You will find the library builder — avr-ar.exe — in the WinAVR bin directory (in my case, C:\WinAVR-20090313\bin\avr-ar.exe). To use this, you must first find the 'Command Prompt' by browsing to the Windows Accessories directory as shown in **Figure 16**, then open it as shown in **Figure 17**.

The library creation program requires a long and difficult to type



■ FIGURE 18. Project Options.

command line. Don't try to type your commands into the Command Prompt since (if you are like me) you will never get it right. Use Notepad to input the command string shown below, then copy and paste it to the cmd window. Assuming that our object files are in 'C:\SPI_library\,' the following string will create our library:



```
avr-ar rcs
C:\SPI_library\libButterflySPI.a
C:\SPI_library\default\spi0_init_master.o
C:\SPI_library\default\spi0_master_rw8.o
C:\SPI_library\default\spi0_master_rw16.o
C:\SPI_library\default\spi0_SS.o
```

NOTE that this must all be on one line and is shown here on several lines since it would be too wide otherwise. Make sure there is a single space between each item. Copy and paste it as shown in **Figure 17**. Push the ENTER button on your keyboard and if it runs okay, you don't get any messages, so you'll want to look in the SPI_library directory and make sure that libButterflySPI.a is really there.

Using libButterflySPI.a

Let's test this by copying the DataFlashTest project from last month's workshop to a new SPI_Library_Test directory so that we can test known good code with the new library [source is in Workshop30.zip]. This works pretty much like last month's DataFlash program except that in the SPI subdirectory, we delete the SPI.c file and copy/paste libButterflySPI.a to replace it. Next, we open the AVRStudio Project menu and select the Project Options. Click on the libraries icon to open the window shown in **Figure 18**.

In the upper part of this window, click on the little folder icon (left of the red X) and navigate to the SPI folder. It will show SPI\ in the upper text box and it will also locate the libButterflySPI.a file and show it in the 'Available link Objects:' list. Highlight the library, then click the 'Add Object' button to add it to the 'Link with these objects' list. Click okay and compile the project. It should compile okay and function exactly like it did when you used the SPI.c file. So it works the same, what did we gain with all this rigmarole? The main thing, as mentioned above, is that now the project will only use (compile in) the functions that you actually need and not clutter things up with unnecessary functions.

Wrap-Up

Now we know a good way to document our software and a way to create libraries. We can document and create libraries for all those Butterfly goodies that we'll want to use in our data logger. If you just can't wait and want to get a good leg up on C and the AVR (while helping support your favorite magazine and technical writer), buy my C Programming book and Butterfly projects kit through the *Nuts & Volts* website. Next month — if all goes well — we will continue with AVR_Toolbox by making it an open source project. **NV**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■ BY L. PAUL VERHAGE

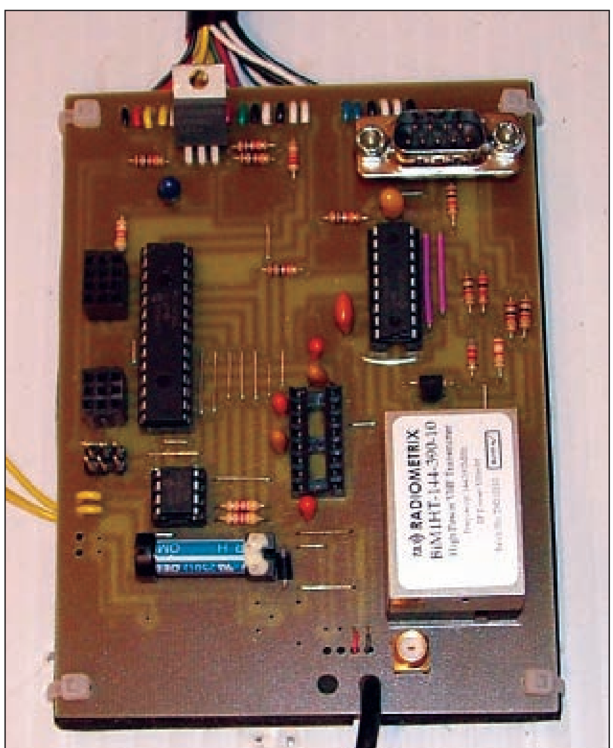
THE NEARSPACE ULTRALIGHT — THE EVERYMAN'S FLIGHT COMPUTER

Since 1996, I've made about one dozen flight computers for near spacecraft. These flight computers combined an APRS tracker with a programmable microcontroller and allowed me to follow the near spacecraft, and the near spacecraft to autonomously operate experiments. With the advent of the Tiny Track 3 by Byonics and the PICAXE-28X by Revolution, a very capable flight computer has become affordable to those wishing to start a near space program. It's a match made in near space.

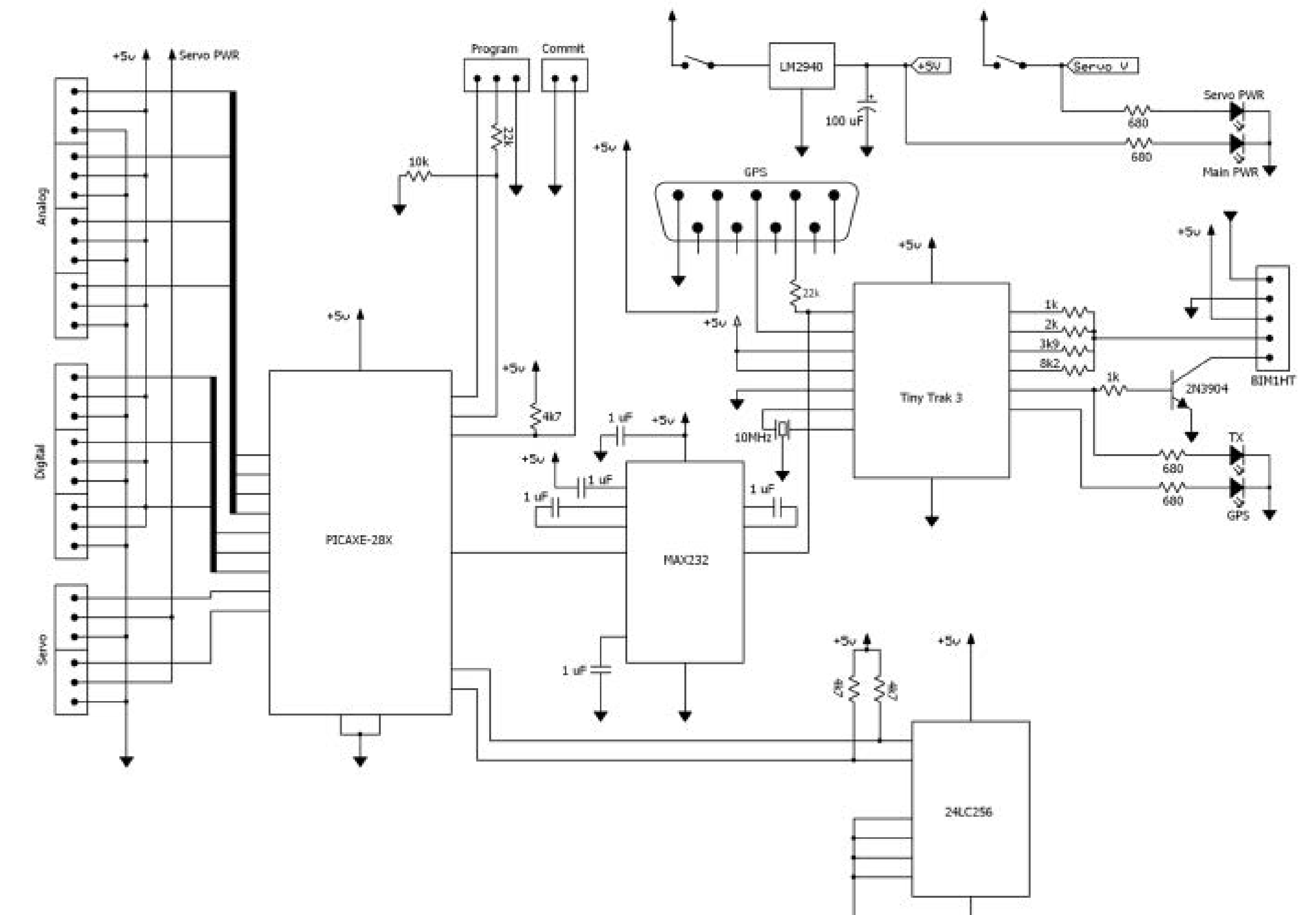
My goal was to create an affordable near space flight computer that was still worth flying into near space. The most affordable PICAXE capable of meeting this need was the PICAXE-28X1. This PICAXE has 2 Kb of memory and up to 12 inputs and 17 outputs (depending on its configuration settings). Of its inputs, four of them can digitize analog sensor voltages in the name of science. However, it wasn't the PICAXE's large number of inputs and outputs that sold me; it was its hardware serial input. HSERIN is a background command that permits the PICAXE to read serial data into its scratch pad while it operates the rest of the mission. GPS data is constantly read into memory for processing at a later time. So, now with a microcontroller selected, it's time to design a flight computer around it.

THEORY OF OPERATION

First, there are power supplies, power switches, and power indicators for both the logic and servos. Separating servo power from the rest of the flight computer ensures the servos can't brown-out the flight computer should they seize up in near space or the battery goes weak. The power switches and indicators are routed (by cables) to the exterior of the airframe. By placing them on the airframe, launch crews switch the near spacecraft on and off without opening up the near spacecraft. In addition to the power switches and indicators, the Commit Pin and programming port are also routed to the airframe. The Commit Pin prevents (if written into the flight program) the UltraLight from recording data while still on the ground. The programming port is a female DB-9 connector and permits sensors to be tested and the flight program updated without



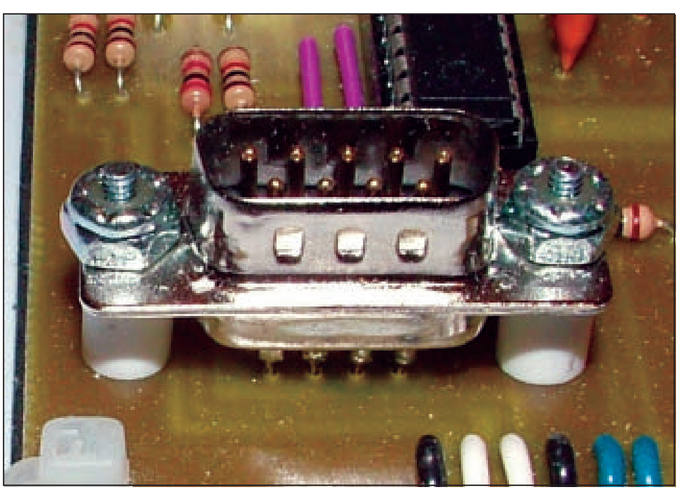
■ The NearSpace UltraLight is a plug and play flight computer. Just plug in the GPS receiver and you're ready for a near space mission. The UltraLight has four analog channels, three digital channels, two servo channels, and two camera channels.



■ The schematic of the NearSpace UltraLight.

opening the airframe. There are two additional LEDs on the airframe. These indicate when the GPS has a lock and when the flight computer is transmitting a position report.

It's more convenient if the flight computer's I/O provides not only access to the PICAXE, but also provides power to all experiments plugged into them. The UltraLight uses the three-pin servo standard for all its I/O channels. Therefore, each channel in the I/O has a connection directly to the PICAXE, +5 volts, and ground.



■ The back of this DB-9 has solder cups that allow wires to be soldered directly to the connector.

The I/O channels on the UltraLight are grouped into four ports based on their function. First, there's the **Analog Port** of four channels. The Analog Port digitizes sensor voltages with a precision of either eight or 10 bits. The second port is the **Digital Port** with its three channels. This is where sensors that produce ON/OFF signals connect to the flight computer. A good example is the Geiger counter; it produces a pulse (0 to 5 volts) upon the detection of a cosmic ray. The third port is the **Servo Port**. It controls the positions of two servos. Servos are useful in near space to position experiments, like cameras, and to release dropsondes.

The final port (and different from the others) is the **Camera Port** which operates the shutters of two cameras. The Camera Port can control two different styles of cameras. First are the traditional cameras with modified shutters. These are cameras in which a cable has bypassed the camera's shutter button. Once bypassed, the cameras depend on the flight computer's relays to trigger their shutters. Alternatively, if a camera's power switch has also been bypassed, the two channels of the Camera Port can power on and off a camera and trigger its shutter.

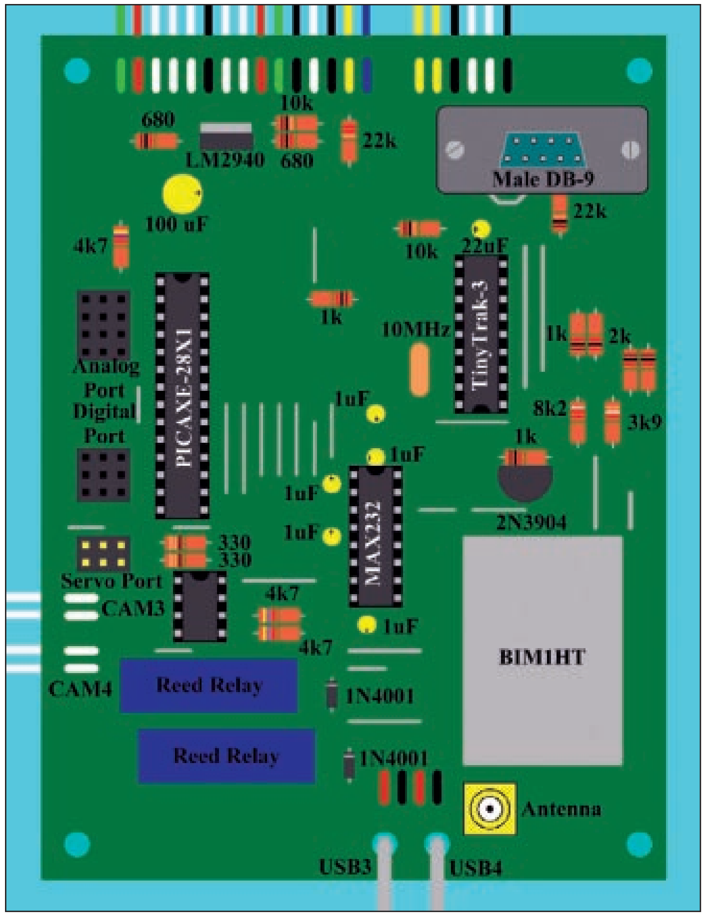
The second type of camera that the UltraLight can operate is a Canon camera running the USB remote.

These cameras use a CHDK script to sense a +5V signal in their mini USB. Usually, the script causes the camera to take a picture, but other features can be coded into the camera's script. Finally, note that the Camera Port is not just for cameras. Any device requiring a switch closure or a five volt signal to operate can replace a camera.

The tracker half of the UltraLight is a Tiny Trak 3 by Byonics. Byon Garrabrant has obviously put a lot of care into the design of the Tiny Trak 3. It's a bullet-proof, transmit only terminal node controller (TNC) that takes GPS data, reformats it for APRS, and then keys the radio and sends the appropriate tones. Since the PICAXE and Tiny Trak 3 run parallel to each other, only a failure of the GPS or main power is going to bring the mission to an early end. So, don't worry if you made an error in your flight code; you'll get your near spacecraft back to fly another day. The 2N3904 transistor between the Tiny Trak and the transmitter inverts the press-to-talk signal from the Tiny Trak. This is necessary to properly key up the BM1HT transmitter. The radio is transmit-only wide band FM and produces a 400 mW signal. The near spacecraft's antenna attaches to the SMA connector next it.

There are two other ICs onboard the UltraLight. The first is a 24LC256 (or other similar IC) with a 32 Kb memory (operating over an I²C network) for storing flight data. Since the Tiny Trak 3 is not used to telemeter science data, that data is stored onboard the flight computer and downloaded after recovery. This ensures your mission data is clean — you don't have to edit out 90% of the position reports in an APRS log just to get your science results. The last IC is the MAX232. This IC inverts the GPS data for the PICAXE-28X1. Without this inversion, the flight computer is not able to take advantage of the HSERIN command.

You should be getting the impression the NearSpace UltraLight is a basic near space flight computer, but still very capable. Those groups new to the near space field will find that the UltraLight makes a perfect first flight computer.

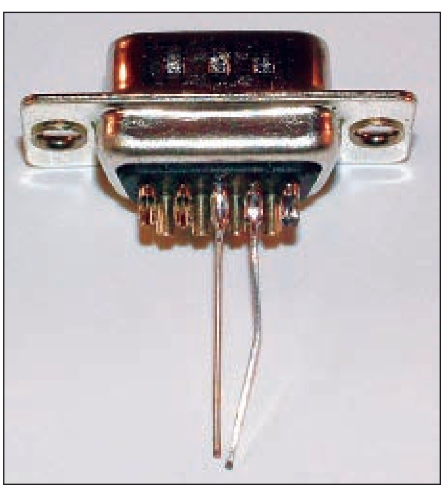


■ The parts placement for the NearSpace UltraLight by NearSys.

CONSTRUCTING THE ULTRALIGHT

Start by acquiring the components listed in the **Parts List**.

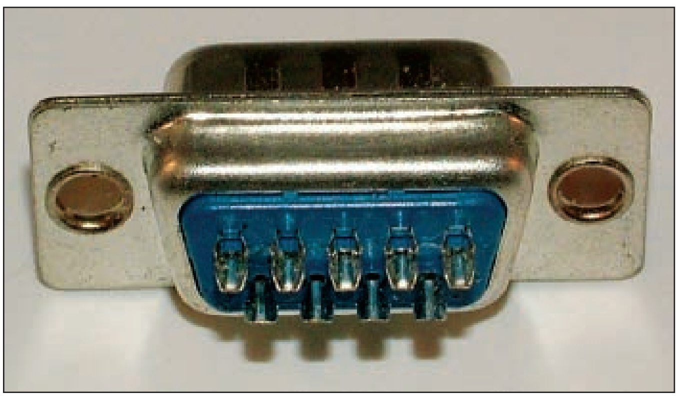
Once you acquire the parts for your UltraLight, make a single-sided PCB from the pattern available in the download on the *Nuts & Volts* website.



■ Two down and seven more to go. It makes installing the DB-9 into the PCB easier if the cut resistor leads are not all the same length. So, don't trim them until after you've soldered the DB-9 to the UltraLight PCB.

There's nothing tricky about assembling the UltraLight. Begin with the jumper wires, resistors, and diodes. Note there's one jumper wire beneath the male DB-9 connector (the **diagram** illustrates it as the wire peeking out from under, at the bottom-left of the connector). Next, add the capacitors. Use tantalum capacitors as they are sealed and can't leak under a vacuum. All seven capacitors are polarized; check the **diagram** for their correct orientation. The 2N3904 transistor is next. Use IC sockets, including one for the transmitter. The transmitter socket consists of

■ This is what the mounted male DB-9 will look like on your UltraLight flight computer.



two single-row receptacles. Remove the 10th pin from one end of the 20-pin receptacle and slice it into two pieces through the empty socket. Repeat this a second time and you'll have two single-row receptacles, nine pins long.

Although not electrically necessary, sand the cut ends of the receptacles to make the radio socket look nice. Now, plug these receptacles into the transmitter, plug the receptacles into the PCB, and just solder the end pins to

Parts List

- Radiometrix BI1HT FM transmitter *
- PICAXE-28X1 microcontroller
- Tiny Trak 3 microcontroller **
- 24LC256 32 Kb memory
- MAX232 RS-232 signal inverter
- 28-pin DIP socket (300 mils wide)
- 8-pin DIP socket (300 mils wide)
- 16-pin DIP socket (300 mils wide)
- 18-pin DIP socket (300 mils wide)
- (4) LEDs (different colors are nice, but not required)
- LM2940 voltage regulator (TO-220)
- 2N3904 NPN transistor
- 100 µF tantalum capacitor (6.3V)
- 22 µF tantalum capacitor (6.3V)
- (5) 1 µF tantalum capacitor (6.3V)
- Ceramic resonator (10 MHz)
- (4) 680 ohm resistors (1/4W)
- 1K resistor (1/4W)
- 2K resistor (1/4W)
- 3K9 resistor (1/4W)
- (3) 4K7 resistor (1/4W)
- 8.2K resistor (1/4W)
- 10K resistor (1/4W)
- (2) 330 resistor (1/4W)
- (2) 22K resistor (1/4W)
- DB-9 (male)
- DB-9 (female)
- One row receptacle (20 pins)
- Right angle header (two pins)
- Shorting block
- 2 x 3 pin header
- (3) AAA battery holder
- 9V battery snap
- SMA connector (145374 from Jameco)
- SMA cable (three feet long)
- Piezo beeper or alarm
- (2) 1N4001 diode
- (3) Sub-miniature toggle switches (SPST or SPDT)
- (2) Reed relay (RadioShack 5V reed relay)
- 3 x 3 pin receptacle
- 3 x 4 pin receptacle
- 3/16" plastic tube 2" long
- (4) #4-40 bolts 1/2" long
- (4) #4-40 nylock
- Hook-up wire (at least 17 feet of #24 AWG stranded)
- 12 gauge solid wire 40" long

* Depending on your location and the frequency of the radio you purchase, you may need to be a licensed amateur radio operator to use this flight computer. You can order the radio through Lemos International, **www.lemosint.com**.
** Available as a chip from Byonics, **www.byonics.com**.

the PCB. Now that the receptacles are properly aligned with the transmitter, carefully remove it and finish soldering the other receptacle pins to the PCB. You can solder the transmitter directly to the PCB, but you won't be able to switch out the transmitter if you want to change the frequency of your UltraLight flight computer at some later time.

On the left side of the flight computer PCB are the I/O ports. The analog and digital ports both use receptacles. I use three-pin wide receptacles when possible and cut them to length. When I can't find three-pin wide receptacles, I use a combination of one-pin wide and two-pin wide receptacles and solder them next to each other. It's a good idea to insert a three-pin header into the receptacles before soldering them. That way, their openings will properly align for sensors. The servo port is a 2 x 3 pin header. I use a longer two-pin wide header and snap it between the third and fourth pairs of pins.

Next, solder the voltage regulator and the SMA antenna connector. Then, solder the male DB-9 connector for the GPS. There are two variations of DB-9 connectors. The first type has nine wire pins sticking out of the back and will solder directly to the UltraLight PCB. The second type has solder cups on the back like the one shown here, and must be prepped before it can be soldered to the PCB.

This type of DB-9 connector is still simple to solder to the PCB, but needs wires soldered to it first. Use cut resistor leads for the wires. The first step is to tin each solder cup. So, heat each cup and apply a thin coating of solder to the inside of the cup. Then, hold (with tweezers or needle-nose pliers) a cut resistor lead to the cup and heat the lead and cup with a well tinned soldering iron. As soon as the solder melts, press the cut resistor lead into the pool of molten solder and hold it steady as the solder cools. Repeat this for the remaining eight solder cups in the back of the DB-9.

Insert the DB-9 into the PCB by working each lead into its respective hole. You may have to wiggle things around a little and use a pair of tweezers on particularly stubborn leads. Once all the leads are in place, press the DB-9 firmly into the PCB and then solder the leads. Cut two pieces of plastic tubing long enough to fit between the wings of the DB-9 and the PCB. Slip the pieces between the DB-9 wings and the PCB, and then bolt the DB-9 to the PCB with #2-56 bolts and nylocks (nylon lock nuts). Don't use regular machine nuts, as they will eventually come loose. It's really bad news if a metal nut comes loose and shorts out a trace underneath the UltraLight flight computer while it is in near space.

That completes the assembly on the PCB. The next step is all the cabling and we'll handle that next time.

Onwards and Upwards,
Your near space guide **NV**

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ELECTRONICS

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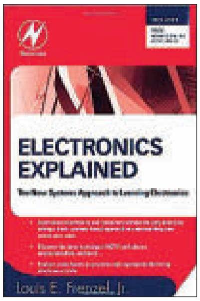

Don't spend time reading about theory, components, and old ham radios - that's history! Industry veteran, Louis Frenzel, gives you the real scoop on electronic product fundamentals as they are today. Rather than tearing electronics apart and looking at every little piece, the author takes a systems-level view. For example, you will not learn how to make a circuit but how a signal flows from one integrated circuit (IC) to the next, and so on to the ultimate goal.

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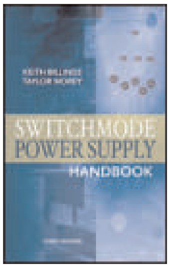

This comprehensive volume explains common requirements for direct operation from the AC line supply and discusses design, theory, and practice. Engineering requirements of switchmode systems and recommendations for active power factor correction are included. This practical guide provides you with a working knowledge of the latest topologies, along with step-by-step approaches to component decisions to achieve reliable and cost-effective power supply designs. **$125.95***

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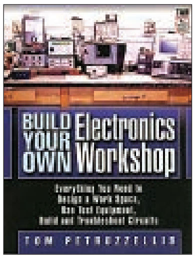

This value-packed resource provides everything needed to put together a fully functioning home electronics workshop! From finding space to stocking it with components to putting the shop into action -- building, testing, and troubleshooting systems. This great book has it all! And the best part is, it shows you how to build many pieces of equipment yourself and save money, big time!

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by Fred Eady

Master and Command C for PIC MCU, Volume 1 aims to help readers get the most out of the Custom Computer Services (CCS) C compiler for PIC microcontrollers. The author describes some basic compiler operations that will help programmers, particularly those new to the craft create solid code that lends itself to easy debugging and testing. As Eady notes in his preface, a single built-in CCS compiler call output_bit can serve as a basic aid to let programmers know about the "health" of their PIC code.

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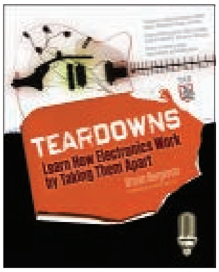

Amp up your knowledge of electronics by deconstructing common devices and analyzing the revealed components and circuitry. *Teardowns: Learn How Electronics Work by Taking Them Apart* contains 14 projects that expose the inner workings of household appliances, workbench measuring instruments, and musical equipment. Discover how resistors, capacitors, sensors, transducers, and transistors function in real circuitry.

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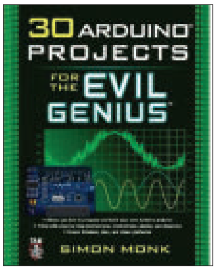
30 Arduino Projects for the Evil Genius
by Simon Monk

30 Ways to Have Some Computer-Controlled Evil Fun!



Using easy-to-find components and equipment, this do-it-yourself book explains how to attach an Arduino board to your computer, program it, and connect electronics to it to create fiendishly fun projects. The only limit is your imagination!

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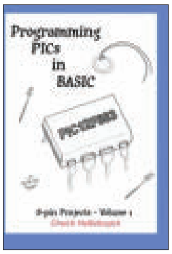
Programming PICs in Basic
by Chuck Hellebuyck



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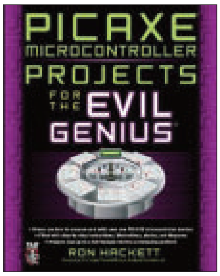
PICAXE Microcontroller Projects for the Evil Genius
by Ron Hackett



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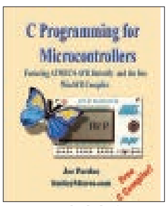

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C Programming for
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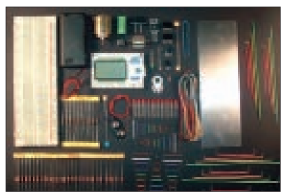

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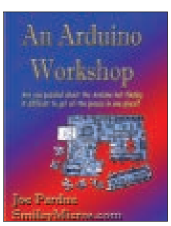

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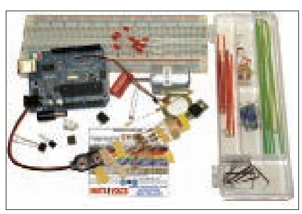
Workshop
by Joe Pardue



The book *An Arduino Workshop* and the associated hardware projects kit bring all the pieces of the puzzle together in one place. With this, you will learn to: blink eight LEDs (Cylon Eyes); read a pushbutton and 8-bit DIP switch; sense voltage, light, and temperature; make music on a piezo element; sense edges and gray levels; optically isolate voltages; fade an LED with PWM; control motor speed; and more!

An Arduino Workshop Combo

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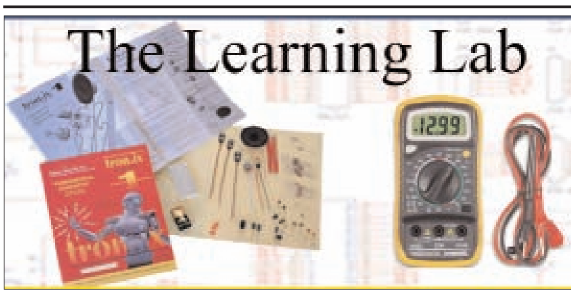

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This lab — from the good people at GSS Tech Ed — will show you 40 of the most simple and interesting experiments and lessons you have ever seen on a solderless circuit board. As you do each experiment, you learn how basic components work in a circuit. Along with the purchase of the lab, you will receive a special password to access the fantastic online interactive software to help you fully understand all the electronic principles. For a complete product description and sample software, please visit our webstore.

This great little book is a concise all-purpose reference featuring hundreds of tables, maps, formulas, constants, and conversions. AND it still fits in your shirt pocket!

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PROJECTS

Mini-Bench Supply Complete Kit

A small power supply with +5V, +12V, and -12V outputs is a handy thing to have around when you're breadboarding circuits with both op-amps and digital ICs.

Kit includes: Enclosure box, accessories, DC-to-DC converter kit, switching regulator kit, and article reprint.
For more information, please see the "feature article section" on the top right side of the *Nuts & Volts* website.

Subscriber's Price **$76.95**
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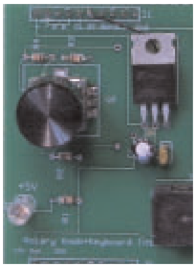
The Mini Kit



NEW!

The best experiment yet for the 16-Bit Experimenter Board.

Adding this Mini Kit to your Experimenter Board will enhance the Experimenter. The Mini Kit is a user interface with a rotary encoder using the PIC24F timer peripheral set and its interrupt capability.
For more information, see the December 2010 issue
Assembled units also available.

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Piezoelectric Film Speaker Kit

As seen in the November issue, here is a great project to amaze your friends and to demonstrate a unique way of producing sound. Kit contains one piece of piezoelectric film, speaker film stand, PCB, components, audio input cable, and construction manual. All you'll need to add is a battery and a sound source.
For more info, please visit our website.

Subscriber's Price **$69.95**
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Garage Door Alarm PCB & Chips

As seen in the November 2010 issue.

Is Your Garage Door Open?

This project uses the latest in wireless technology, and is a fun and easy project to build. We provide the difficult parts: the transmitter and receiver PCBs with their matching programmed MCUs. The other components can be fould at your favorite parts house.

Includes an article reprint.

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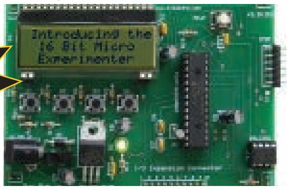
16-Bit Micro Experimenter Board

Now available! Assembled boards!



Ready to move on from 8-bit to 16-bit microcontrollers? Well, you're in luck! In the December 2009 *Nuts & Volts* issue, you're introduced to "the 16-Bit Micro Experimenter."
The kit comes with a CD-ROM that contains details on assembly, operation, as well as an assortment of ready-made applications. New applications have been added since inception.

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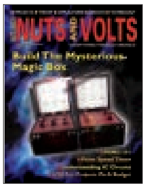
Magic Box Kit



As seen on the April 2007 cover

This unique DIY construction project blends electronics technology with carefully planned handcraftsmanship. This clever trick has the observer remove one of six pawns while you are out of the room and upon re-entering you indicate the missing pawn without ever opening the box.

Includes an article reprint.

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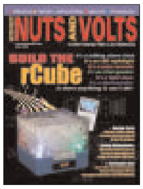
rCube Talking Alarm Clock Kit

As seen on the May 2009 cover



Available in blue, black, red, and green. All components are pre-cut and pre-bent for easier assembly and the microcontrollers are pre-programmed with the software. Kits also include PCB, AC adapter, and instructions on CD-ROM.

Subscriber's Price **$49.95**
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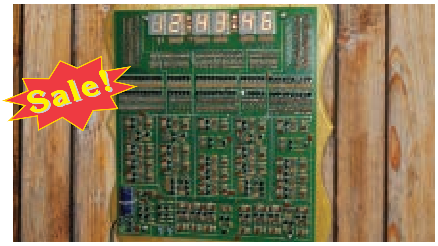
Transistor Clock Kit

Sale!



If you like electronic puzzles, then this kit is for you! There are no integrated circuits; all functionality is achieved using discrete transistor-diode logic. The PCB is 10"x11" and harbors more than 1,250 components! For more info, see the November 2009 issue.

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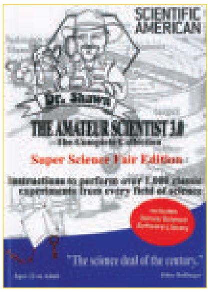
by Bright Science, LLC



There are 1,000 projects on this **CD**, not to mention the additional technical info and bonus features. It doesn't matter if you're a complete novice looking to do their first science fair project or a super tech-head gadget freak; there are enough projects on the single CD-ROM to keep you and 50 of your friends busy for a lifetime!

Reg Price $26.95
Sale Price $23.95

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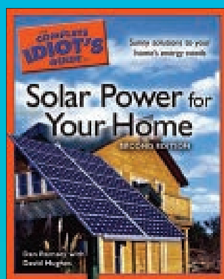
ALTERNATIVE ENERGY SECTION

The Complete Idiot's Guide to Solar Power for Your Home
by Dan Ramsey / David Hughes

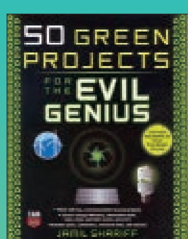


The perfect source for solar power — fully illustrated. This book helps readers understand the basics of solar power and other renewable energy sources, explore whether solar power makes sense for them, what their options are, and what's involved with installing various on- and off-grid systems.
$19.95

NEW!
Green Lighting
by Brian Clark Howard, Seth Leitman, William Brinsky
Flip the switch to energy-efficient lighting!

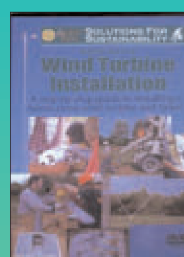
This do-it-yourself guide makes it easy to upgrade residential and commercial lighting to reduce costs and environmental impact while maintaining or even improving the quality of the lighting. Filled with step-by-step instructions and methods for calculating return on investment, plus recommended sources for energy-efficient products.
$24.95

50 Green Projects for the Evil Genius
by Jamil Shariff



Using easy-to-find parts and tools, this do-it-yourself guide offers a wide variety of environmentally focused projects you can accomplish on your own. Topics covered include transportation, alternative fuels, solar, wind, and hydro power, home insulation, construction, and more. The projects in this unique guide range from easy to more complex and are designed to optimize your time and simplify your life!
$24.95

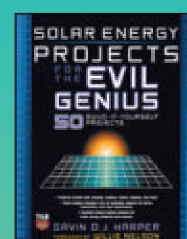
NEW!
Wind Turbine Installation DVD



Manuals can sometimes be confusing, especially for people who learn by seeing how things work. So, this DVD takes the viewer step-by-step through the entire installation process, from choosing a site, to running wire, assembling the tower, and finally using a winch for the final lift. This is a must-watch for anyone planning on installing a wind turbine who wants to learn the process and the proper techniques for a safe and successful installation.

$19.95*

Solar Energy Projects for the Evil Genius
by Gavin D J Harper



Let the sun shine on your evil side — and have a wicked amount of fun on your way to becoming a solar energy master! In *Solar Energy Projects for the Evil Genius*, high-tech guru Gavin Harper gives you everything you need to build more than 30 thrilling solar energy projects. You'll find complete, easy-to-follow plans, with clear diagrams and schematics, so you know exactly what's involved before you begin.
$24.95

Hydrocar Kit

The Hydrocar is used in a couple of great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 10 and 11, he teaches you the operation of the Polymer Electrolyte Membrane "reversible" fuel cell. For kit details and a demo video, please visit our webstore.

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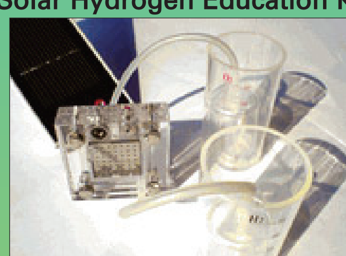
Solar Hydrogen Education Kit



The Solar Hydrogen Education Kit includes a solar cell, a PEM reversible fuel cell, oxygen and hydrogen gas containers, and more! The set only needs pure water to create hydrogen and produce electricity. Perfect for science labs, classroom use, or demonstration purposes.
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The WindPitch Wind Turbine Kit is a miniature real-working wind turbine and is one of the great projects from the series of articles by John Gavlik, "Experimenting with Alternative Energy." In Parts 8 and 9, he teaches you how to produce the most power by evaluating the pitch (setting angle) of the profiled blades. For kit details, please visit our webstore.
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Non-Subscriber's Price **$89.95**

>>> QUESTIONS

75 ohm Coax Connections

Seems like I always have reliability issues with 75 ohm coax connections.

I'm certain the problem is the center conductor. I have roughed it up with serrated pliers, bent the end a little, etc., but still have a problem.

I'm thinking about applying solder paste to the end, to maybe seal out oxygen, and the little solder balls make the connection.

All the quality parts/crimps are just not reliable.

#1111 **Frederick M. Raposa**
Vallejo, CA

Electric Fence

I need to show when an electric fence (6 KVa to 16 KVa) is active by flashing a simple LED with every pulse. Ideally, the circuit would simply attach between high V and ground strands of the fence. A perfect solution would be able to cope with an inadvertent reverse connection.

It would be good to be able to use multiple such devices at regular intervals along the fence. I am looking for lowest cost/complexity.

#1112 **Kevin Dickinson**
Australia

>>> ANSWERS

[#9108 - September 2010]
Voltage Dropping

I have two circuits in the same enclosure: one works on 12 VDC and the other on 9 VDC. I have a 12 VDC transformer for one, but need to lower the output to 9 VDC for the other. I tried with resistors to lower the voltage to 9 VDC with no success.

No mention was made of the current requirements, but if they aren't too demanding you can get 9 VDC quite easily from the 12 VDC using a three-terminal regulator such as the 7809, plus a small capacitor (0.01 µF) on the output. Use the 7809 for up to 1A with a heatsink. For lower currents (up to 100 mA), you might get by with the 78L09. Alternatively, you can use diodes in series to give you your voltage drop. Depending on the type of diode used, four to six in series should be sufficient. If your circuit does not already include one, add a capacitor to ground after the last diode for filtering. An electrolytic with few to a few hundred µF (depending on the current) should be sufficient.

Bryan Suits
Houghton, MI

[#10101 - October 2010]
Reactive Transformerless Power Supply

How does one calculate the value for the reactance capacitor in an AC to DC reactive power supply so as not to over-work the zener diode? I've used from .68 µf to 4.7 µf for various voltages out, but it has always been trial and error.

#1 ***Before starting, some advice:*** These supplies have no isolation from the line and should only be used to power loads that are completely isolated from the user. Have the bridge rectifier end of the supply connected to the neutral side of the line. Use an isolation transformer when testing the circuit; be careful even with the isolation transformer, there are still lethal voltages present. It is strongly advised to include a fuse in series with the limiting capacitor or use "across the line" capacitors — also called "X" capacitors.

A very good approach is to start from the output and work back to the source. Determine the maximum output current desired. Add 3 to 5 mA for the zener, to keep it at the zener voltage even at full load. This is the average current needed out of the full-wave bridge rectifier feeding the zener. Subtract the zener voltage plus two diode drops from the minimum line voltage; I usually use 105 or 106V. For example, a 12V zener plus 1.4V (that is, two times 0.7V) from 105V leaves 91.6V across the capacitor.

The average current is about 90% of the RMS current, so multiply average current by 1.111 to get the RMS current in the capacitor. The equivalent reactance Xc = Vcapacitor/Irms. At 60 Hz, we know that Xc = 1/377C, so C = 1/377Xc. Or, C = Iav x 1.111/(377 x Vcapacitor).

Using our 12V example and a 20 mA maximum load current, we get Iav = 20+3 = 23 mA and Irms = 25.553 mA. Using Iav and Vcapacitor in the formula, C = ~0.74 µF. Note that this makes no allowances for capacitor tolerance. A "turnkey" solution would add 10% for capacitors with a 10% tolerance, so all values would work. In this case, the nearest standard value would be 0.82 µF. If a one-off circuit is built, one can select a capacitor or parallel combination very close to the desired value and the worst case current at high line voltage will be a bit less. Also, the zener losses at minimum load will be less.

Next, the zener wattage has to be determined. This one assumes all tolerances and line voltage go to the worst case: capacitor is 0.82+10%; line voltage is ~10% high; and load current is at minimum. For the example, assume .902 µF, 130V and minimum load current is 5 mA.

Send all questions and answers by email to **forum@nutsvolts.com**
*Check at **www.nutsvolts.com** for tips and info on submitting to the forum.*

Icapacitor is 91.6 x 377 x 0.902 µF =~31.15 mA RMS. This is an average current of ~28 mA, so the zener is drawing 28 mA - 5 mA =23 mA and dissipates 12V x 23 mA = 0.276W. A conservative choice is to keep the actual power in the zener at half of the zener's rating. That would suggest a 1/2W zener for this example.

A capacitor will go across the zener to reduce ripple voltage to an acceptable level; a good place to start for this example might be 150 or 220 µF at 20 or 25V. (It's good practice to derate capacitors, too — run them at no more than 2/3 of their rating.)

Lastly, add a surge limiter in series with the capacitor; 47 ohms, 1/2W is a good starting point. This limits peak currents in the capacitor and diodes during turn-on and when line transients occur.

J Wexler
via email

#2 There are two relatively easy ways to approach this issue. The first one involves determining the capacitive reactance from frequency (60 Hz) and capacitance (the *ARRL Handbook* has a handy nomograph). Then, use Ohm's Law to calculate the current flowing in the AC and DC loop. The AC loop current needs to match max DC load plus knee current of the zener diode. The difference between max DC and min DC load added to the knee current needs to be smaller than the current handling capability of the zener. The easier way is to model the circuit on a circuit simulator such as LT Spice IV. This will produce start-up curves, maximum currents, etc., and you can look at all the voltages, voltage differentials, and currents at any moment in time by clicking on it. **Figure 1** shows the principle.

Walter Heissenberge
Hancock, NH

#3 If a zener diode regulator is unloaded as in **Figure 2**, all the current will pass through the zener diode instead of the load plus zener. This is the worst possible case that needs to be designed for, and is less complicated than the case where some current passes through the load, some through the zener. The power rating of the zener diode must not be exceeded by zener voltage times zener current. For a given zener diode voltage, I = P/V. For example, a 5.1V half watt zener may safely pass a current of I= 0.5/5.1= 0.098A = 98 mA. (To be conservative, you might want to cut that in half.)

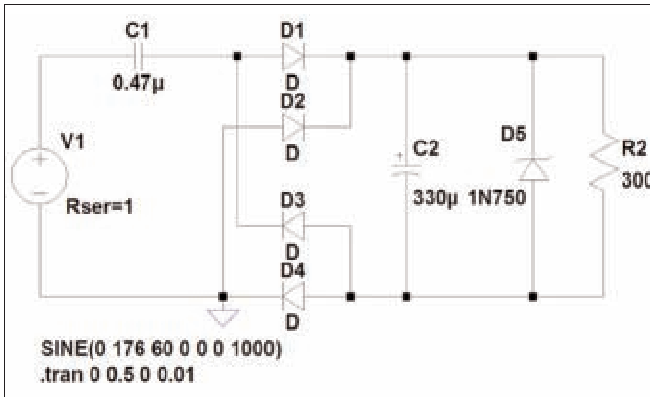


Figure 1 Transformerless Power Supply

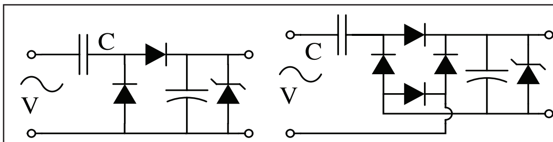
Reference **[1]** gives an equation for the RMS short circuit current drawn by capacitor C in terms of RMS line voltage, frequency, and capacitor C for a half-wave configuration as shown in the **figure**. Reference **[2]** gives a similar equation for the full-wave circuit. By short circuit, we mean that the zener diode is replaced by a short circuit. For the moment, we will simplify the problem by assuming that a zener draws the same current as the short circuit.

For the full-wave circuit, substituting 50 mA (about half of the 98 mA), 120V, and 60 Hz; and solving for C, we get C = 1.23 µF. Selecting a 1 µF standard value, re-solving the full-wave equation for current, we get I = 40.7 mA for short circuit current. A 5.1V zener diode will draw less current due to the 5.1V zener voltage subtracting from the line voltage.

A more exact solution involves replacing V in the equations by (V-Vz) to correct for the voltage dropped across the zener. You can also subtract off the forward rectifier voltage drop. However, the (V-Vz) only improves the accuracy of the calculation by about 12/120 = 10% for a 12V supply, 5/120 = 4% for a 5V supply. Considering the poor tolerance on capacitors, the effort is not warranted for 12V or lower supplies.

The filter capacitor in parallel with the zener diode can be an electrolytic type in the range of 220 µF to 1,000 µF according to reference **[1]**. Guidance on calculating the value with respect to ripple voltage is given in the references. Not shown in the **figure**, reference **[1]** recommends a 100 ohm resistor in series between the output filter capacitor and zener diode. *Both of the references can be found by seaching for the title on the Internet.*

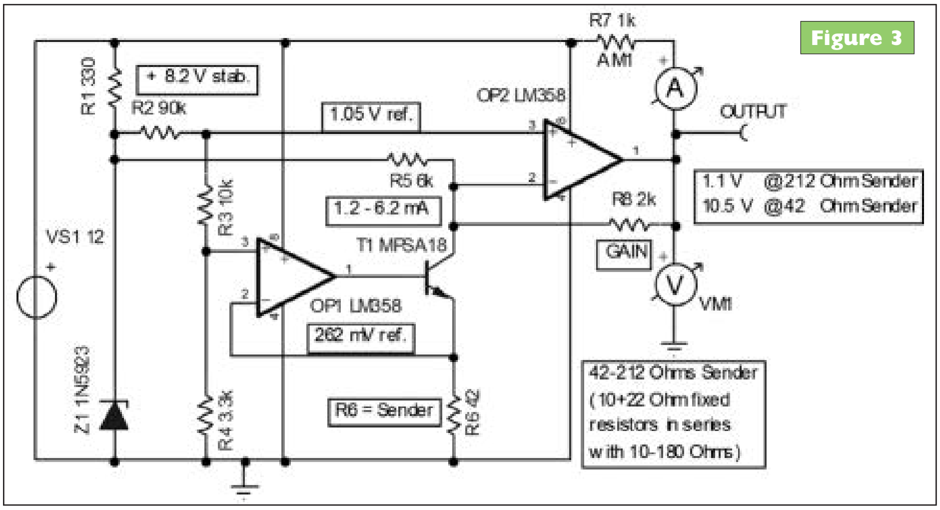
Practical considerations: Type X2



$I_{HW} = 2 \cdot \sqrt{2} \cdot V \cdot C \cdot f$ $\quad$ $I_{FW} = 2 \cdot \sqrt{2} \cdot V \cdot C \cdot f$

Where:
V = RMS input voltage
C = Capacitance in Farads
f = frequency
I_{HW} = halfwave short circuit current
I_{FW} = fullwave short circuit current

Figure 2



capacitors are recommended for C by reference [1]. They will have an AC voltage rating. If using a capacitor with only a DC rating, select a 330 VDC capacitor for use with 120 VAC. Reference [2] recommends ceramic or film capacitors. Safety regulations require a 470K ohm or other appropriate resistor in parallel with C for a one second or less discharge time. Do not connect any line operated test equipment to this circuit unless using an isolation transformer.

Reference [2] recommends a resistor in series with C to limit power-on surge current to 10x normal current. That is, set R = 0.10*Xc, where Xc = 1/(2*pi*f*C). This is mandatory when powering LEDs from an unfiltered supply. Do not use this circuit with high brightness LEDs. They cannot withstand the surge current even with the limiting resistor.

Safety: Let me quote reference [1]. "***WARNING:*** *As with all circuits powered directly from the AC power line, a potentially lethal shock hazard exists. Be sure to observe correct power-line polarity. An isolation transformer is recommended when working on or testing the circuit. Follow all local electrical codes."*

References:

[1] Brian King and Robert Kollman, "Simple Off-Line Power Supply Minimizes Costs", pp 69, *Electronic Design*, 02.02.04.

[2] Nathan O Sokal, et. al., "Step-down rectifier makes a simple DC power supply," pp 169, *EDN*, April 9, 1998.

Dennis Crunkilton
Abilene, TX

[#10102 - October 2010]
Ping Tester

I work in large building complexes and need to "ping" devices several floors away or in the next building. I typically use a laptop, but it's difficult to hold or set down while in riser or mechanical rooms. There are cable testers with ping functionality but they are costly. It would be a neat project to build a ping tester using one of the widely available development boards and microcontrollers. There are so many choices I don't know where to start. Could someone point me in the right direction?

Construction of a battery powered "ping tool" would be a great project to undertake. There are many good serial-to-Ethernet converter solutions out in the world but none appear to offer raw IP-level packet generation, which is what you'll need to play in the ICMP game to implement ping. I recommend you start with a Luminary LM3S6965 development board. They have a ridiculously powerful 32-bit Cortex-M3 CPU onboard along with 10/100 Ethernet, OLED display, and some pushbuttons. The board runs $70 from Digi-Key and comes in many flavors; I found the Keil IDE to be top-notch.

Entering the target IP address may be cumbersome so I propose the following software structure: After booting, use DHCP to obtain an IP address and then repeatedly scan the subnet looking for responders to your ping command. Continually update an internal list of responses (and age out the non-responders) so that a real-time display of the subnet can be shown.

It would be easy then to use the pushbuttons to slide your display-sized window through the list.

Dan Danknick
Santa Ana, CA

[#10104 - October 2010]
Resistance Inverter/Converter

I installed a dash from a Buick into a Winnebago. The gas gauge in the new dash requires 242 ohms for a full and 42 for an empty reading. The Winnebago sending unit gives a 10 ohms full and 180 ohms empty resistance reading. I need help in designing a circuit to do this conversion.

#1 I think the easiest way to solve your gas gauge problem will be to get a sender from the proper model Buick. Either a new one or from a salvage yard. You then need to remove the sender from the Winnebago and replace the potentiometer on it, with the one from the Buick sending unit. That should work and should be doable. At the worst case, you might need to open the case of the potentiometer and swap the resistance element if the assembly does not mount the same way. Test the gauge readings before reinstalling. You may need to slightly alter the connections at the potentiometer to get Full and Empty in the correct direction. Possibly adjust the float arm as well for Full and Empty.

Bruce Bubello
Wayne, NJ

#2 Convert the variable resistance to current, scale, invert, shift, and amplify. Then, reconvert to a current. *Op-Amp Handbooks* — the Burr-Brown Handbook reissued by Texas Instruments — and early National

Semiconductor Appnotes are all available on the web and can serve as good references). **Figure 3** shows a possible approach. A zener stabilizes the supply voltage and provides two reference voltages: one for the constant current source of about 262 mV and a higher one of 1.05V. This will yield a current of 1.2 to 6.2 mA injected into the inverting input of OP2. The current through R5 serves as an offset adjustment (current) and is constant. The difference in currents needs to be provided through R8. In short, OP2 sums up three currents through R5, R8, and the collector of T1 so that they are zero. The result is an inverted voltage output against 12V. A resistor in series with AM1 reconverts into a current. You may need to adjust the values of R5, R8, and R7. A buffer is required on OP2's output if higher currents are necessary.

Walter Heissenberger
Hancock, NH

>>> COMMENTS

In regards to John Hobday's query about hum detection in the September '10 issue, I have recently suffered from the same problem — a low-level pervasive 50 Hz-ish hum (our mains frequency as I'm in the UK too) which was only audible inside the house. I located it to an area of interior hollow plasterboarded wall which could conceivably contain a central heating pump. We don't have cellars/basements in the UK — unlike many US homes — and sometimes people do the weirdest things to make upgrades fit.

Anyway, I was about to reluctantly tear into this plasterboarded wall when I decided to just turn off all building power to try to isolate exactly which circuit was causing the noise. Perhaps I could just turn that circuit off and deal with it when I had more time and enthusiasm? (If you have a good day in the UK summer, make the most of it — they're that rare.) But with no result!!??? The problem was not electrical in nature, but had a more down to earth solution. The 50 Hz was a red-herring. It was all down to plumbing. By law, in the UK, all outside taps have to have an integral non-return valve built into them. My outside tap (over a room away) was weeping very slowly, and this small plastic valve was chattering at 50 Hz. It wasn't audible at the tap but the effective water hammer only became noticeable at this hollow wall which must have acted as a resonator into the ceiling/floor cavities.

The moral is that a bit of lateral thinking can save the day, even when you already 'know' what the problem is. I would NOT have been pleased to discover the real cause AFTER tearing into a perfectly well decorated wall!

Ms. Sally Jelfs
UK subscriber

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Triple Output Bench Power Supplies

The new CSI3303S & CSI5505S regulated DC power supplies are high reliability, variable DC Power Supplies with built in short circuit and thermal protection. These power supplies are suitable for the laboratory, electronics, communications equipment maintenance, production line, scientific research and educational institutions. Both units are equipped with protection circuits that protect the units from short circuits and over temperature by shutting the unit down for safety. Both units allow independent, serial and parallel mode operation.

Technical Specifications:

Independent mode: 2 independent 0-30V outputs

Series mode: CSI3303S Output from 0-60V & 0-3A
CSI5505S Output from 0-60V & 0-5A
Parallel mode: CSI3303S Output from 0-6A & 0-30V
CSI5505S Output from 0-10A & 0-30V

Both units also provide a 5V fixed output @ 3A

Load regulation: <0.1%+3mV (rating current <3A)
<0.2% +3mA
Ripple and noise: <1mVrms 5Hz-1MHz
<3mArms

Voltage accuracy: +/-0.5%rdg+2byte
Current accuracy: +/-.5%rdg+2byte

Display resolution: +/-0.5%rdg+2byte
Rated output: 5.0V +/-0.1V 3A

Tracking characteristics
Series specifications:
Load regulation: less than 50mV
Ripple and noise: (5Hz~1MHz) <=3mVRMS

Parallel characteristics:
Load regulation: less than 50mV
Ripple and noise: (5Hz-1MHz) CV less than 1mV<=6A), CV less than 1.5mV (I>6A)

Once again Circuit Specialists brings you a quality product at a great price!

Item#
0 to 3A **CSI3303S** **$169.00**
www.circuitspecialists.com/CSI3303S 4+ $155.00 ea.

Item#
0 to 5A **CSI5505S** **$194.00**
www.circuitspecialists.com/CSI5505S 4+ $179.00 ea.

New Year, New Price

CSI-Station1A

Easily our best value in our selection of soldering stations. O.E.M. manufactured just for Circuit Specialists Inc., so we can offer the best price possible! The CSI-Station1A features a grounded tip & barrel for soldering static-sensitive devices and uses a ceramic heating element for fast heat up & stable temperature control.

The control knob is calibrated in Fahrenheit & Celsius (392° to 896°F and 200° to 480°C). One of the nicest features is the high quality comfort grip soldering iron. The iron connects to the station via an easy screw-on connector making iron replacement a snap. The 1 meter length iron cord provides plenty of length for users to set up the station in a convenient location. Another nice feature is the soldering iron holder. Made of rugged aluminum,it is a seperate piece from the main station & allows the user maximum convenience.....you don't have to reach all the way back to the station to store the iron. Yet another feature is the stackable design of the CSI-Station1. The main station is designed for an additional unit to be placed on top of it allowing for space saving placement of the CSI-Station1A. Also included at no additional charge is one user replaceable ceramic heating element so that you will be prepared!

- **Made for us so we can offer the best possible price**
- **Temperature Stable Ceramic element**
- **Easy to Replace Soldering Iron (not hard wired)**
- **Grounded Tip & Barrel to prevent ESD damage**
- **24V Iron Operation**
- **Soft Comfort Grip Pencil Iron**
- **Iron Holder is Detached, Rugged aluminum construction**
- **Includes one FREE replacement ceramic heating element**

CSI-STATION1A
$29.95
New Year, New Price

The following soldering tips are also available


0.8mm Chisel Tip (KD-M-0.8D)


1mm Single Flat 40º Tip KD-M-1C


1.2mm Chisel Tip KD-M-1.2D


1.6mm Chisel Tip KD-M-1.6D


2mm Single Flat 40º Tip KD-M-2C


2.4mm Chisel Tip KD-M-2.4D


3mm Single Flat 40º Tip KD-M-3C


3.2mm Chisel Tip KD-M-3.2D


4mm Single Flat 40º Tip KD-M-4C


Conicle Fine Point Tip KD-M-1


Conicle Fine Point Tip KD-M-B


Long Conilce Fine Pt Tip KD-M-LB

USB Digital Storage Oscilloscopes

* High performance:
* USB connected: Uses USB and supports plug'n play, with 12Mbp communication speed.
* Best performance for your dollar: Thease units have many features that are comparable to the high speedah stand-alone DSOs. But costs a fraction of the price.
* No external power required: Bus-powered from the host computers USB port.
* Probes & USB cable included.
* Easy to use: Intuitive and easy to understand.
* Various data formats: Can save wavrfrom in the following formats: .txt .jpg .bmp & MS excel/word

40MHz **DSO-2090** **$169.00**
www.circuitspecialists.com/DSO-2090

60MHz **DSO-2150** **$209.00**
www.circuitspecialists.com/DSO-2150

100HMz **DSO-2250** **$259.00**
www.circuitspecialists.com/DSO-2250

200MHz **DSO-5200** **$299.00**
www.circuitspecialists.com/DSO-5200

200MHz **DSO-5200A** **$355.00**
www.circuitspecialists.com/DSO-5200A

Specifications	DSO-2090	DSO-2150	DSO-2250	DSO-5200 /5200A
Channels	2 Channels			
Impedence	1M 25pF			
Coupling	AC/DC/GND			
Vertical resolution	8 Bit			9 Bit
Gain Range	10mV-5V, 9 Steps			10mV-10V, 10Steps
DC Accuracy	+/- 3%			
Timebase Range	4ns - 1h 38 Steps			2ns-1h, 39 Steps
Vertical adjustable	Yes			
Input protection	Diode clamping			
X-Y	Yes			
Autoset	30Hz~40MHz	30Hz~60MHz	30Hz~100MHz	30Hz~200MHz
EXT. input	Yes			
Trigger Mode	Auto / Normal / Single			
Trigger Slope	+/-			
Trigger Level Adj.	Yes			
Trigger Type	Rising edge / Falling Edge			
Trigger Source	Ch1 / Ch2 / EXT			
Pre/Post trigger	0-100%			
Buffer size	10K-32K per ch			10K-512KB per ch
Shot Bandwidth	DC to 40MHz	DC to 60MHz	DC to 100MHz	100MHz
Max Sanple Rate	100MS/s	150MS/s	250MS/s	200MS/s / 250MS/s
Sampling Selection	Yes			
Waveform Display	port/line, waveform average, persistence, intensity			
Network	open / close			
Vertical Mode	Ch1, Ch2, Dual, Add			
CursorMeasurement	Yes			
Spectrum Analyzer				
Channels	2 Channels			
Math	FFT, addition, subtraction, multiplication, division.			
Bandwidth	40 MHz	60 MHz	100MHz	200 MHz
Cursor	Frequency, Voltage			
Data Samples	10K-32K/Ch			10K-1M/Ch

CircuitSpecialists.com

1000's of Items Online! 1-800-528-1417 Fax: 480-464-5824 Since 1971

We carry a LARGE selection of Power Supplies, Soldering Equipment, Test Equipment, Oscilloscopes, Digital Multimeters, Electronic Components, Metal and Plastic Project Boxes, Electronic Chemicals, PC Based Digital I/O Cards, Panel Meters, Breadboards, Device Programmers, and many other interesting items. Check out our website at: *www.CircuitSpecialists.com*

3 Channel Programmable Regulated DC Power Supplies

NEW ITEM

Check out our new programmable hi preformance 3 channel power supplies. Featuring both USB & RS232 interfaces, Overload Protection, Auto Fan Control, and Series or Parallel Operation. Both units feature a Large LCD display panel with simultaneous output and parameter view and a keypad for control. They are ideal for applications requiring high resolution, multiple output, and automated operation such as in production testing. There are both fine and coarse controls via the shuttle knob and 90 memory settings. Software included.

Reliable, Highly Stable, Fan Cooled.

Model	CSIPPS33T	CSIPPS55ST
DC Voltage	0-32V x2 0-6V x1	0-32V x2 0-6V x1
DC Current	0-3A x3	0-5A x2 0-3A x1

Item # **CSIPPS33T** **$479.00**

www.circuitspecialists.com/CSIPPS33T

Item # **CSIPPS55T** **$619.00**

www.circuitspecialists.com/CSIPPS55T

Programmable DC Electronic Loads

Thease devices can be used with supplies up to 360VDC and 30A. It features a rotary selection switch and a numeric keypad used to input the maximum voltage, current and power settings. These electronic DC loads are perfect for use in laboratory environments and schools, or for testing DC power supplies or high-capacity batteries. It also features memory, and can also be connected to a PC, to implement remote control and supervision.

360V/150W (CSI3710A) $349.00

www.circuitspecialists.com/csi3710a

360V/300W (CSI3711A) $499.00

www.circuitspecialists.com/csi3711a

200MHz Hand Held Scopemeter with Oscilloscope & DMM Functions

NEW ITEM

Includes 1 Year USA Warranty

You get both a 200 MHz Oscilloscope and a multi function digital multimeter, all in one convenient lightweight rechargeable battery powered package. This power packed package comes complete with scopemeter, test leeds, two scope probes, charger, PC software, USB cable and a convenient nylon carrying case.

- 200MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 200MHz Bandwidth with 2 Channels
- 500MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # **DSO1200** **$739.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter with Oscilloscope & DMM Functions

- 60MHz Handheld Digital Scopemeter with integrated Digital Multimeter Support
- 60MHz Bandwidth with 2 Channels
- 150MSa/s Real-Time Sampling Rate
- 50Gsa/s Equivalent-Time Sampling Rate
- 6,000-Count DMM resolution with AC/DC at 600V/800V, 10A
- Large 5.7 inch TFT Color LCD Display
- USB Host/Device 2.0 full-speed interface connectivity
- Multi Language Support
- Battery Power Operation (Installed)

Item # **DSO1060** **$529.00**

www.circuitspecialists.com/DSO1200

60MHz Hand Held Scopemeter w/Oscilloscope, DMM Functions & 25 MHz Arbitrary Waveform Generator

- All the features of the DSO1060 plus a 25 MHz Arbitrary Waveform Generator.
- Waveforms can be saved in the following formats: jpg/bmp graphic file, MS excel/word file
- Can record and save 1000 waveforms
- DC to 25 MHz Arbitrary Waveform Generator

Item # **DSO-8060** **$659.00**

www.circuitspecialists.com/DSO-8060

Programmable DC Power Supplies

- Up to 10 settings stored in memory
- Optional RS-232, USB, RS-485 adapters
- May be used in series or parallel modes with additional supplies.
- Low output ripple & noise
- LCD display with backlight
- High resolution at 1mV

Model	CSI3644A	CSI3645A	CSI3646A
DC Voltage	0-18V	0-36V	0-72V
DC Current	5A	3A	1.5A
Power (max)	90W	108W	108W
Price	$199.00	$199.00	$199.00

BlackJack SolderWerks

Hot Air System with Soldering Iron & Mechanical Arm

The BK5000 from BlackJack SolderWerks provides a very convenient combination of hot air and soldering in one compact package. The hot air gun is equipped with a hot air protection system which provides system cool-down and overheat protection. The system cool-down feature removes the residual heat from the nozzle after the hot air function is switched off. This will cool the nozzle more rapidly & extend the life of the heating element. The overheat protect feature effectively shuts off power to the heater when an overheat in the middle of the handle has been detected. The hot air gun is designed to use different SMD nozzles for various SMD applications. The soldering iron incorporates a replaceable tip design & uses the same series of tips that are compatible with BlackJack models BK2000 & BK2000+

Mechanical Arm with Air Gun attached

SPECIFICATIONS:

Power Input : 110V
Dimensions: 188mm (w) x 126mm (h) x250mm (d)
Weight: 4.8Kg

SOLDERING IRON
Power Consumption: 35W
Temperature Range: 200 - 480 degrees Celsius
Heating Element with Tip: Ceramic Heater
Output Voltage: 24V
Tip to Ground Resistance: Below 2 ohms
Tip to Ground Potential: Below 2mV

HOT AIR
Power Consumption: 500W peak
Temperature Range: 100 - 500 degrees Celsius
Heating Element Metal Heating Core
Nozzle to Ground Resistance: Below 2 ohms
Pump/Motor Type: Diaphragm Pump
Air Capacity: 23 L /min (max)

A wide selection of accessories, soldering tips & hot air nozzels are also available

Item # **BK5000** **$97.00**

www.circuitspecialists.com/bk5000

0-30V / 0-5A . DC Power Supply

The CSI530S is a regulated DC power supply which you can adjust the current and the voltage continuously. An LED display is used to show the current and voltage values. The output terminals are safe 4mm banana jacks. This power supply can be used in electronic circuits such as operational amplifiers, digital logic circuits and so on. Users include researchers, technicians, teachers and electronics enthusiasts. A 3 ½ digit LED is used to display the voltage and current values.

ww.circuitspecialists.com/csi530s

Item # **CSI530S** **$84.95**

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210
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